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TOXICOLOGY

Volume II: Antibiotics

EDITED BY
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Compiled from the Literature by
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Prepared under the Direction of the Committee
on the Handbook of Biological Data

DIVISION OF BIOLOGY AND AGRICULTURE
THE NATIONAL ACADEMY OF SCIENCES
THE NATIONAL RESEARCH COUNCIL

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Foreword

This compilation of data on antibiotics--their physical, chemical, biological and toxicological properties--comprises Volume II of the Handbook of Toxicology. The Handbook was prepared under Aero Medical Laboratory Contract No. AF 33(616)-2875 between The National Academy of Sciences and the Wright Air Development Center, United States Air Force. Under the same contract additional volumes are scheduled for publication in the coming year. The contract was administered under the direction of the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, Dr. George Kitzes acting as Project Director, Project No. 7159, "Health Hazards of Air Force Materials." The United States Army Chemical Center has also generously assisted in support of this contract.

Data for all volumes were contributed by experts in various areas of the fields represented. The material was reconciled, assembled, compiled, and edited by the Handbook Staff and reviewed and authenticated by specialists in the subjects covered. The work was carried out under the direction of the Committee on the Handbook of Biological Data, operating under the Division of Biology and Agriculture of The National Academy of Sciences-National Research Council.

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May 28, 1957

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Introduction

This volume presents data on the physical, chemical, biological, and toxicological properties of 340 antibiotics. The word "antibiotic" is used in the strictest sense, i.e., "a chemical substance produced by microorganisms which has the capacity, in dilute solutions, to inhibit the growth of, or to destroy, bacteria and other microorganisms." Other anti-infectives and chemotherapeutic agents have not been listed in this book.* The data herein are recorded as accurately as possible from the literature and are current as the book goes to press. Because the field of antibiotics is tremendously fast-moving, it is by no means beyond possibility that some of the biological and toxicological information may be out of date by the time the volume appears in print--or that some of the facts may be contradicted by more recent reports.

The guiding principles in selection of material have been that it be of basic importance and from reliable literature sources. Some data of value have had to be omitted either because they were not on hand for publication or because time has not permitted the necessary preparatory steps for printing. The fact that certain data have been compiled and are already in print, or available in other form, has not been regarded as a reason for excluding them from this Handbook. Every page of this volume has been examined for accuracy by the contributors.

In the compilation of this information, one of the chief objectives has been clarity of presentation. To attain this clarity, only the most fundamental data appear in the body of the text. In several instances footnotes have been used to supply additional facts and preserve the conciseness of the text. Other pertinent material prohibited by limitations of space is to be found in the literature, and for this reason the bibliography is presented in sets of references, with a set for each antibiotic listed. Chemical nomenclature has been kept exactly as contributed and is, in every case, identical with that commonly found in the literature. However, a cross index at the back of the book contains numerous synonyms and proprietary names to facilitate location of any compound listed.

In an attempt to increase the usefulness of the volume, two appendices have been added. The first of these is an antibiotic efficacy listing in which organisms are compiled alphabetically and each is followed by the code numbers of all antibiotics showing moderate to high activity against it. The second appendix is a source list of antibiotics, alphabetized by the source organism.

It must be emphasized that the data presented in these tables, particularly those values concerned with toxicology, are by no means absolute and should be interpreted only as a "yardstick" of activity for the compounds listed. Again, the literature reference, in most cases, will reveal the number of determinations, the number of animals in each determination, and conditions under which determinations were made. Some of the conditions which influence toxicity or biological effect of any given compound are as follows:

a. Dose: Generally, the larger the dose the more rapid the action.
b. Rate of absorption: The faster this rate, the quicker the action of the drug. With oral administration the lethal dose may be considerably influenced by the condition of the gastrointestinal tract, especially by the amount of food and fecal material in the stomach and intestine.
c. Route of administration: For the most part, toxicity or efficacy is greatest by the route that carries the active substance to the bloodstream most rapidly. In descending order of speed of action, routes for most drugs are: intravenous, inhalation, interperitoneal, intramuscular, subcutaneous, oral, and cutaneous. Food in the alimentary canal may delay or decrease activity; digestive enzymes may destroy or alter the compounds with resultant changes in the effectiveness thereof. Certain compounds are harmless if taken orally and lethal when introduced parenterally; in some cases the converse is true. The efficacy of the drug may also vary considerably with the form in which it is administered, i.e., solid, in suspension, or in solution. In the last instance the activity again may be influenced by the solvent and the concentration.
d. Site of injection: With subcutaneous injections, toxicity may be affected by the density of the subcutaneous tissue. With intravenous administration, whether the injection is made into the femoral or jugular vein may be of importance, but in any case the rate of injection, or the amount of toxic material injected per minute, will considerably influence the value of the toxic dose.
e. Other important influences: Idiosyncrasy, disease, environmental temperature, habit and tolerance, diet, season of the year (especially with hibernating animals) may all affect the activity or toxicity of an antibiotic. These properties will also vary with the species of animals used, and sometimes with different strains of the same species and within the same strain they may differ with age, weight, sex, and the general condition of the animals.

With all of the above variables exerting their individual or collective influences, it is important that the activity be delineated with reference to the time of death, the period of time for which fatalities are counted, or whatever other end-point is employed.

Unfortunately, only in rare instances are all these factors considered and specified in the literature on toxicity determinations. This renders the duplication of such data by different investigators extremely difficult if not impossible. At the present time, attempts are being made to put toxicity data on a quantitative basis. The older literature often refers simply to "lethal doses" (LD) or "minimal lethal doses" (MLD), meaning doses which will be fatal or the smallest dose which will kill a limited number of animals. By using a larger number of animals of comparative weight and sex for each level tested, attempts are now being made to determine more precisely the dose which will kill 50 per cent (LD_{50}). These values can be further certified by the application of various statistical methods, by stating the degree of deviation of single values from the mean or the slope of the toxicity curve.

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*Data on these compounds will be presented in a forthcoming volume entitled "Anti-infectives."

The data in this Handbook are, in the judgment of the contributors, as authentic as can be procured under the conditions as they exist. It is recognized, however, that all data, and particularly those in the fields of toxicology and antibiotics, are subject to continuing revision as investigators standardize techniques and make more measurements. The user of the volume is warned against attributing significance to small differences from species to species. He is invited to submit any data he feels should be given consideration.

TOXICITY CLASSES

The toxicological data presented in this Handbook are the result of extensive tests on laboratory animals. Frequently, toxicologists, industrial hygienists, industrial physicians, etc., are asked to translate these data into terminology that will readily describe the hazards associated with their use. Consequently, classes have been established to define the toxicity of a chemical material, in common terms, with reference to data obtained by specified animal tests. The following tabulation of toxicity classes is useful only for those data which are applicable.

COMBINED TABULATION OF TOXICITY CLASSES*

Various Routes of Administration					
Toxicity Rating	Commonly Used Term	LD_{50} Single Oral** Dose Rats	Inhalation 4-hr Vapor Exposure Mortality 2/6-4/6 Rats	LD_{50} Skin Rabbits	Probable Lethal Dose for Man
1	Extremely toxic	1 mg or less/kg	<10 ppm	5 mg or less/kg	A taste, 1 grain
2	Highly toxic	1-50 mg	10-100	5-43 mg	1 teaspoon, 4 cc
3	Moderately toxic	50-500 mg	100-1000	44-340 mg	1 ounce, 30 g
4	Slightly toxic	0.5-5 g	1000-10,000	0.35-2.81 g/kg	1 pint, 250 g
5	Practically non-toxic	5-15 g	10,000-100,000	2.82-22.59 g/kg	1 quart
6	Relatively harmless	15 g and more	>100,000	22.6 or more g/kg	>1 quart

* Hodge, H. C., and Sterner, J. H., American Industrial Hygiene Association Quarterly, 10:4, 93, Dec. 1943.

** Standards for intravenous LD_{50} for rats and rabbits may be obtained approximately by dividing the oral toxicity standards for rats by 10.

Antibiotics

1. ABIKOVIROMYCIN

SOURCE Streptomyces rubescens, n. sp, and S. abikoensum, n. sp [1] .

STABILITY Unstable to heat, acid, exposure in dry state [1] .

OTHER REACTIONS Red color on heating 5 minutes at 100°C in 1% phosphate buffer at pH 7; positive Molisch, Tollens, Ag mirror; sublimes during freeze drying. [1]

BIOLOGICAL ACTIVITY In vitro. Weak antibacterial and antifungal activity. Inhibits, at 62.5-250 μg/ml, Shigella dysenteriae, Salmonella paratyphi, S. typhimurium, Klebsiella pneumoniae, Proteus vulgaris, Bacillus anthracis, Mycobacterium phlei, and Candida albicans. Brucella melitensis, Pseudomonas aeruginosa, Bacillus subtilis and Micrococcus pyogenes var. aureus are not sensitive, requiring 500 μg/ml or more. Inhibits western and eastern equine encephalitis virus in dilution of 1:8,000,000. No activity against Venezuelan equine encephalitis and Japanese encephalitis viruses.[2] Poliomyelitis virus rendered non-infective to mice when mixed with crude filtrates. Partially purified product exhibited antiviral activity in dilution of 1:25,000.[3]

ACUTE TOXICITY LD_{50} in mice, approximately 6.6 mg/kg, i.v., and 66 mg/kg, s.c. [1] .

2. ACHROMOVIROMYCIN

SOURCE Streptomyces achromogenes, n. sp [1] .

REACTIONS Extractable with ethyl acetate at pH 2; related to, but not identical with, abikoviromycin and sarcidin [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits only Sarcina lutea, no other bacteria or fungi. Crude preparation inhibited Japanese B encephalitis virus in mice in dilution of 1:16,000 [1] .

ACUTE TOXICITY Mice tolerated s.c. doses of approximately 100 mg/kg [1] .

3. ACTIDUINS

SOURCE Streptomyces sp [1] .

COLOR Yellow to reddish substances [1] .

MELTING POINT (°C) None definite; darken at approximately 280, but no melting at 350.[1]

SOLUBILITY s. strong mineral acids; sl. s. butanol, ethanol, pyridine, acetic acid, cyclohexanone, dimethylformamide; i. water, ether[1].[1]

STABILITY Stable at acid and neutral pH; unstable at alkaline pH [1] .

OTHER REACTIONS Yellowish fluorescence in organic solvents, less so in aqueous solvents; activity may be obscured in beers by faster diffusing substances; contain C, H, N, S, and one contains Cl; precipitated by dilution after dissolving in strong acids; crystalline reineckates soluble in acetone. Infrared peaks: actiduin II, 6.04, 6.54, 6.86, 7.05, 7.27, 7.47, 7.67, 8.1, 8.3, 8.6, 8.73, 9-9.14, 9.45, 9.87, 10.91, 11.9, 12.2, 12.7, 13.33 μ; actiduin III, 6.04, 6.41, 6.86, 7.04, 7.27, 8.1, 8.3, 8.61, 8.71, 9-9.14, 9.45, 10.91, 11.9, 12.2, 12.7, 13.33, 13.91, 14.37 μ; actiduin VI, 6.04, 6.54, 6.86, 7.28, 7.48, 7.67, 8.05, 8.3, 8.58, 9-9.14, 9.4, 9.85, 10.1, 10.9, 12.67, 13.3, 13.9 μ. On hydrolysis they yield both a ninhydrin positive and a fluorescent, somewhat acidic material, the former separating into acidic and neutral fractions on paper ionophoresis.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus[2] [1] .

BIOLOGICAL ACTIVITY Actiduins II, III, IV, VI inhibit M. pyogenes var. aureus in dilution of 1:60,000,000-1:360,000,000. Also highly active against Streptococcus pyogenes, Diplococcus pneumoniae, Corynebacterium xerose. No activity against Gram-negative bacteria and Mycobacterium tuberculosis.[1]

4. ACTINOLEUKIN

SOURCE A strain of Streptomyces aureus [1] .

MOLECULAR FORMULA $(C_9H_{12}N_2O_3)_n$ [1] .

CRYSTAL FORM AND COLOR White platelets or needles [1] .

MELTING POINT (°C) 191-192 (d.)[3] [1] .

/1/ Different actiduins, however, are soluble in acetone, methanol, or chloroform, and can be separated on this basis. /2/ Preferably using serial tube dilution. /3/ After repeated crystallization.

4. ACTINOLEUKIN (Concluded)

UV ABSORPTION MAXIMA 243, 312 mμ [1] .

SOLUBILITY s. methanol, ethanol, butanol, acetone, ethyl acetate, butyl acetate, dioxane; sl. s. benzene, chloroform; i. ether, petroleum ether, water.[1]

OTHER REACTIONS Positive $FeCl_3$; negative ninhydrin, biuret, Tollens, Fehling; purple ring in Molisch test. Analysis: C, 55.53, 55.68; H, 6.05, 5.98; N, 14.05, 14.01.[1]

BIOLOGICAL ACTIVITY *In vitro*. Inhibits Micrococcus pyogenes var. aureus, Sarcina lutea, Bacillus anthracis, B. subtilis at 0.005-0.04 μg/ml. Gram-negative bacteria not susceptible.

In vivo. Slight inhibition of Ehrlich carcinoma in mice when 6 μg daily were injected, i.p., for 9 days.[1, 2]

ACUTE TOXICITY LD_{50} in mice, 1 mg/kg, i.v. [1] .

5. ACTINOMYCELINE

SOURCE Streptomyces sp related to S. antibioticus [1] .

NATURE Neutral, yellowish-green pigment [1] .

SOLUBILITY s. water, ethanol, methyl acetate; less s. acetone; sl. s. amyl acetate, chloroform; i. ether, benzene.[1]

STABILITY Thermolabile; stable at pH 7, less stable at pH 2.0; destroyed in 0.1 N NaOH in 24 hours.[1]

OTHER REACTIONS Intense fluorescence in ethanol [1] .

BIOLOGICAL ACTIVITY *In vitro*. Active against Gram-positive bacteria; no activity against fungi and mycobacteria.[1]

ACUTE TOXICITY Rats tolerated s.c. doses of 25 mg/kg [1] .

6. ACTINOMYCETIN

SOURCE Streptomyces albus [3] .

NATURE Probably polypeptide enzyme [1] .

SOLUBILITY s. water; i. ether, ethanol.[1]

STABILITY Thermo- and acid labile [1] . Inactivated by UV shorter than 300 mμ [2] .

OTHER REACTIONS Precipitated by acetone, ethanol, $(NH_4)_2SO_4$; repeated precipitation with $(NH_4)_2SO_4$ yields 10-fold increase in activity.[1, 4]

BIOLOGICAL ACTIVITY Contains a lytic substance, "actinozyme," which dissolves dead and, to a lesser extent, living bacteria, e.g., Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Diplococcus pneumoniae, Bacillus megatherium [4] .

7. ACTINOMYCINS[1]

SOURCE Streptomyces antibioticus, S. chrysomallus [12, 14, 21] .

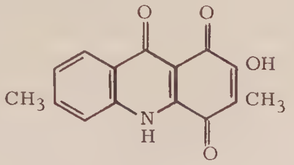
NATURE Weakly basic chromopeptides, quinonoid [4, 7, 12] .

MOLECULAR FORMULA AND WEIGHT

Actinomycin A: $C_{41}H_{58}N_8O_{11}$ [4] ; 1000 ± (Rast); 768-780, 813 (cryo.); 716 ± 15 (cryst.).[1, 2, 6]
B: $C_{61}H_{88}N_{12}O_{16}$ or $C_{65}H_{88}N_{12}O_{20}$; 1240 ± 20 (found); 1245, 1356 (calc.).[7, 9]
C: $C_{62}H_{89}N_{11}O_{17}$ or $C_{60}H_{83}O_{16}N_{11}$; 915 (Beckman); 876-944 (Barger-Rast); 1260.4, 1214 (calc.).[5]
C_2: 1296 ± 35 [26] .
C_3: $C_{64}H_{90}O_{16}N_{12}$ [32] ; 1307 ± 35. [26]
D: $C_{60}H_{76}O_{15}N_{12} \cdot 3H_2O$ (proposed); approximately 1200 (by analogy).[23]
J_1: 1305 ± 35.
X_1: 1320 ± 35.
X_2: 1307 ± 35.
$X_{o\beta}$: 1393 ± 35.[26]

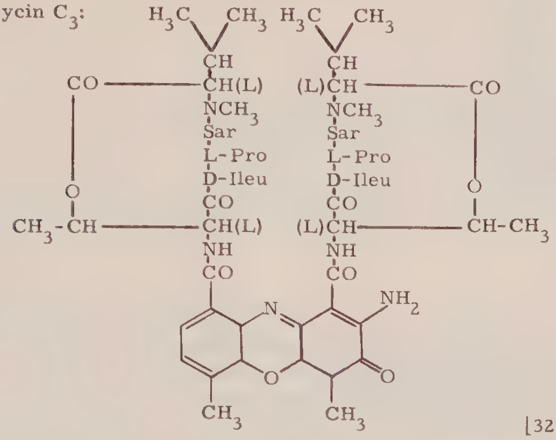
/1/ Actinomycin C also known as actinochrysin, Sanamycin.

STRUCTURE Actinomycins appear to have a common chromophore but differ in peptides. Peptide-free chromophore (actinomycinol) postulated to be:


O
O
OH
CH3
CH3
N
H
O

[25]

Actinomycin C_3:


H3C
CH3
H3C
CH3
CH
CH
CO
CH(L)
(L)CH
CO
NCH3
NCH3
Sar
Sar
L-Pro
L-Pro
D-Ileu
D-Ileu
O
O
CO
CO
CH3-CH
CH(L)
(L)CH
CH-CH3
NH
NH
CO
CO
N
NH2
O
O
CH3
CH3

[32]

CRYSTAL FORM AND COLOR

Actinomycin A: red-vermilion platelets[1] [1,2].

B: red plates[2], orange needles[3] [8].

$C_1, C_2, C_3, I_o, I_1, X_1$: hexagonal bipyramids, six-angled prisms or needles[4] [10,11,13].

D: bright red rhomboid prisms [23].

X_2: rhombic plates[5] [10,11,13].

$X_{o\beta}$: yellow needles [31].

MELTING POINT (°C)

Actinomycin A: 250, 252 (d.) [1-3].

B: 250-252 (d., corr.) [8].

C_1: 241-243 (d.)[6] [10,13].

C_2: 237-239 (d.)[6] [10,13].

C_3: 232-235 (d.)[6] [10,13].

D: 241.5, 243 (d.) [23].

I_o: 242-243 (d.)[6] [10,13].

I_1: 240.5-242 (d.)[6] [10,13].

X_1: 240-242 (d.)[6] [10,11,13].

X_2: 244-246 (d.)[6] [10,11,13].

$X_{o\beta}$: 245-247 [31].

OPTICAL ACTIVITY

Actinomycin A: $[\alpha]^{25}_{D} = -320^{\circ} \pm 5$[2] [1].

B: $[\alpha]^{31}_{D} = -332^{\circ}, -340^{\circ}$ [3,8].

C_1: $[\alpha]^{20}_{D} = -349^{\circ} \pm 10$ [10,13].

C_2: $[\alpha]^{19}_{D} = -325^{\circ} \pm 10$ [10,13].

C_3: $[\alpha]^{19}_{D} = -321^{\circ} \pm 10$ [10,13].

D: $[\alpha]^{28}_{D} = -315^{\circ} \pm 10$[7] [23].

I_o: $[\alpha]^{20}_{D} = -314^{\circ} \pm 10$ [10,13].

I_1: $[\alpha]^{20}_{D} = -353^{\circ} \pm 10$ [10,13].

X_1: $[\alpha]^{20}_{D} = -309^{\circ} \pm 10$ [10,13].

X_2: $[\alpha]^{19}_{D} = -341^{\circ} \pm 10$ [10,13].

$X_{o\beta}$: $[\alpha]^{20}_{D} = -261^{\circ} \pm 10$[8] [31].

/1/ From ether-acetone or ethyl acetate. /2/ Ethanol. /3/ Butanol. /4/ Ethyl acetate, methanol, benzene. /5/ Ethyl acetate. /6/ Koffler-Block MP determinations. /7/ c, 0.25 methanol. /8/ c, 0.22 acetone.

SPECIFIC EXTINCTION[1] AND Rc2 VALUES[2]

Actinomycin	C_oa:		0.13, 0.10 [13] .
	Co:		0.13, 0.10 [13] .
	C_1:	20.5	0.72, 0.56 [10, 13] .
	C_2:	19.9	1.00, 1.00 [10, 13] .
	C_3:	18.8	1.39, 1.61 [10, 13] .
	I_oa:		-, 0.12 [13] .
	I_o:	20.5	0.49, 0.27 [10, 13] .
	I_1:	20.7	0.74, 0.63 [10, 13] .
	I_2:		1.00, 0.97 [13] .
	I_3:		-, 1.34 [13] .
	X_oa:		0.14, 0.17 [13] .
	X_o:		0.14, 0.39 [13] .
	X_1:	17.3	0.48, 0.56 [10, 11, 13] .
	X_1a:		-, 0.71 [13] .
	X_2	18.6	0.72, 0.98 [10, 11, 13] .
	X_3:		0.93, 1.49 [13] .
	X_4:		1.11, 1.90 [13] .

UV ABSORPTION MAXIMA

Actinomycin A: 230-250, 450 mμ[3] [1, 2] .
B: 240, 447 mμ[3] [8] .
D: 240-242, 422 mμ [23] .

SOLUBILITY Actinomycin A, B: s. chloroform, benzene, ethanol, acetone, hot ethyl acetate, 10% HCl; sl. s. water, ether; i. petroleum ether, dilute mineral acids, dilute alkali.[1, 2, 8, 12]

C: s. benzene, chloroform, acetone; less s. ethanol, glacial acetic acid; sl. s. water, carbon disulfide.[5]

STABILITY Thermostable except in alkali and strong acid [1, 2, 12] .

AMINO ACID CONTENT Actinomycin A, B, C_1, I_o, I_1, X_1, X_2: threonine, sarcosine, proline, valine, n-methyl-valine [1, 4, 7, 10, 13] .

C_2: threonine, sarcosine, proline, valine, n-methyl-valine, allo-iso-leucine [13] .

C_3: threonine, sarcosine, proline, n-methyl-valine, allo-iso-leucine [10, 13] .

OTHER REACTIONS Actinomycin A: Transient purple color with concentrated NaOH; negative color reaction with alcoholic $FeCl_3$; reduced by sodium hydrosulfite, stannous chloride or hydrogen over platinum oxide to pale yellow, reversed by exposure to air; no reaction with sodium bisulfite.[1, 12]

C: Negative ninhydrin; gray-brown precipitate with Nessler, yellow-green fluorescence in methanol or glacial acetic acid.[5]

E_1, E_2: Produced biosynthetically from a C-producing Streptomyces strain by use of DL-isoleucine in medium [33] .

F_o-F_5: Produced by same strain as above when sarcosine is the precursor [33] .

I: Identical with A [13] .

J: May be identical with A [39] .

X mixture: Identical with B [13] .

$X_{o\beta}$: Can be acetylated; has higher threonine content than other actinomycins and contains an amino acid not present in the others; with acetic anhydride-pyridine produces a crystalline yellow acetate, MP 229°C.[31]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis, Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Actinomycin A: Inhibits (μg/ml) Streptococcus sp, and Diplococcus pneumoniae at 1; B. subtilis and Sarcina lutea at 0.01-0.02; Aerobacter aerogenes and Escherichia coli, 200 [14] . Inhibited certain fungi at 20-100 μg/ml: Aspergillus niger, Fusarium sp, Penicillium sp, and Trichoderma sp. Slight activity against Candida albicans, Trichophyton mentagrophytes, and Cryptococcus neoformans.[14, 17]

B: A mixture of A and biologically inactive substances; shows low biological activity.

C: Inhibited (μg/ml) M. pyogenes var. aureus at 0.05, B. subtilis at 0.01, E. coli at 100.[21, 22]

In vivo. Actinomycin A: Inactive against Str. pyogenes and D. pneumoniae infections in mice; slight protection afforded in infections with Trypanosoma equiperdum.[16] Showed no activity in chicks infected with Plasmodium gallinaceum [34] .

C: Shows cytostatic activity against malignant tumors. Daily i.p. doses of 75-100 mg/kg for 7 days inhibited sarcoma 180 in mice; 25-75 mg/kg/da suppressed RC carcinoma and prolonged survival time in mice with leukemia L-4946.[35] In rats with Walker carcinoma, oral, i.v. or s.c. treatment with 50 μg/kg considerably suppressed tumor development [18] . No antitumor activity observed in chick embryos.[24] Intracardiac injections, in doses of 10 μg, delayed deaths from anaphylactic shock in guinea pigs [27] . No activity in mice infected with viruses of influenza (PR-8) and rabies [24] .

/1/ At 446 mμ in cyclohexane. /2/ First column: butanol, n-dibutyl ether (2:3)/10% sodium-m-creosotinate; 2nd column: butyl acetate, n-dibutyl ether (3:1)/10% sodium-m-creosotinate. /3/ Ethanol.

D: Showed a low therapeutic index in experimental tumors in mice, with activity following dosages of 0.5-0.75 mg/kg. The most sensitive neoplasms were a glioblastoma, a C_3H adenocarcinoma and S-91 melanoma, with moderate tumoristatic activity against sarcoma 180 and $6C_3HED$ lymphosarcoma. Failed to prolong life in mice bearing L-1210 leukemia.[36] Daily doses of 0.025 mg/kg in mice and rats had a marked suppressive effect on Ridgeway osteogenic sarcoma and ascites tumor, and little or no effect on solid tumors.[37, 38]

J: Single doses of 5 μg or 0.03-0.5 μg/da, i.p., inhibited Ehrlich ascites carcinoma in mice; the suppression was only slight when therapy was delayed for 24 hours or longer. Daily doses of 0.125-1.0 μg inhibited subcutaneous solid tumor of Ehrlich carcinoma and Yoshida rat sarcoma. Also active against Usubuchi rat sarcoma and Takeda rat liver sarcoma.[39] Daily doses of 0.025 mg/kg in mice and rats had a marked inhibitory effect on Ridgeway osteogenic sarcoma and ascites tumor and little or no effect on solid tumors.[37, 38]

CLINICAL Actinomycin C: Encouraging results in a few patients with lymphogranulomatosis (Hodgkin's disease); total doses of 1900-4350 μg per patient were used, with no toxic reactions observed.[19] In another series of 30 patients with lymphogranulomatosis, given daily i.v. doses of 50-400 μg, some objective as well as subjective improvement described [28] . Favorable clinical responses reported in patients with malignant conjunctival tumors following intravenous therapy with 0.2 mg/kg/da, increasing to 0.4-0.6 mg/kg [40] . In further preliminary observations, inconclusive results obtained in patients with a variety of inoperable malignant conditions, following daily i.v. doses of 200 μg for 25 days. These doses appeared to be well tolerated.[24] Daily i.v. injections of 40-150 μg appeared to exert beneficial effect in several cases of bronchial asthma [27] .

D: Daily i.v. doses of 25-400 μg, over periods of 9-30 days, failed to alter significantly the course of Hodgkin's disease in 3 patients [29] .

ACUTE TOXICITY Actinomycin A: LD_{100} in mice, 1-2 mg/kg, i.v.; 0.5-5.0 mg/kg, s.c. [14-16] Following 0.125 mg/kg doses in mice, 10-20% excreted in urine in 6 hours [16] . Liver damage, altered kidney function, and eventual death in rats given daily doses of 0.025-0.1 mg/kg, i.p.[15] .

C: LD_{100} in mice, 5 mg/kg, i.p.; 50 mg/kg, oral doses.[20, 22] Injection of 30 μg in mice produces a marked diminution in spleen size within 3 days [27] . In vitro. Bone marrow cells in tissue culture were unaffected by concentrations of 0.025 μg/ml, but proliferation was retarded by concentrations of 0.25-2.5 μg/ml. No hemolysis of rabbit erythrocytes in concentrations of 500 μg/100 ml.[30]

D: LD_{50} in mice, 0.67-0.74 mg/kg, i.v. Marked reduction in size of spleen in mice following i.v. dose of 0.5 mg/kg.[23]

J: LD_{50} in mice, 0.8 mg/kg, i.v. or i.p.; 1.37 mg/kg, s.c. LD_{50} in rats, 0.58 mg/kg, i.v.; 0.53 mg/kg, i.p. Five daily i.v. doses of 16 μg/kg lethal in dogs, 2-4 μg/kg tolerated, 8 μg/kg nephrotoxic. Three daily doses of 2 μg/kg in rabbits had no adverse effect on the blood picture.[39]

CHRONIC TOXICITY Actinomycin C: In man, following intravenous therapy, thrombocytopenia, stomatitis and brown pigmentation of the skin have been reported after dosages totaling 7-10 mg over long periods [43] . I.v. doses in excess of 400 μg may also produce nausea, diarrhea, pharyngitis, alopecia and vaginitis. Intravenous injection is the route of choice in view of localized reactions following intramuscular or subcutaneous use.[40, 42]

Daily i.v. doses of 20 μg/kg for 60 days were well tolerated in rabbits; 40 μg/kg induced anemia which persisted until antibiotic was discontinued. Doses of 80 μg/kg produced bone marrow changes and reduction in size of lymph glands, but had no appreciable effect on spleen size.[30]

ABSORPTION AND EXCRETION Actinomycin C: Rapidly eliminated in urine following i.v. therapy in man [40] .

MODE OF ACTION In microbiologic systems using a variety of organisms, a competitive inhibition of pantothenate by actinomycin D was demonstrated. In addition to excess pantothenate, the inhibition could be reversed noncompetitively by certain amino acids, dicarboxylic acids, orotic acid, or adenine.[41]

8. ACTINONE

SOURCE Streptomyces sp related to S. antibioticus [1] .

SOLUBILITY s. ether, butyl acetate; less s. benzene, petroleum ether, ethyl acetate; i. chloroform.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Saccharomyces sp and Trichophyton sp in dilutions of 1:1,000,000-1:1,500,000. Inactive against other fungi and bacteria.[1]

ACUTE TOXICITY Low toxicity; mice tolerated i.v. and s.c. doses of 1000 mg/kg [1] .

9. ACTINORHODIN

SOURCE Streptomyces coelicolor[1] [3] .

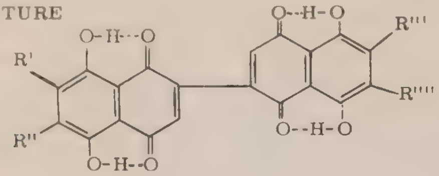
NATURE Red pigment [2] ; acidic [4] .

/1/ From mycelium.

9. ACTINORHODIN (Concluded)

MOLECULAR FORMULA AND WEIGHT $C_{32}H_{30}O_{14}$, $C_{32}H_{26}O_{14}$ or $C_{32}H_{28}O_{14}$; 566, 587 (found).[4]

STRUCTURE



$$\underbrace{R',\ R'',\ R''',\ R''''}_{2\text{-}CO_2H,\ 2\text{-}CH_3,\ C_8H_{16}O_2}$$ [4]

CRYSTAL FORM AND COLOR Fine red needles [1] ; microscopic prisms [3] .

MELTING POINT (°C) 270 (d.) [2] .

ABSORPTION MAXIMA 531, 571 mμ[1] [1] .

SOLUBILITY s. pyridine, tetrahydrofuran, dioxane, alkali; sl. s. water, alcohol, acetone; i. ether, petroleum ether.[1]

STABILITY Rapidly changed in weak alkaline solution, but stable in n-alkali; partially destroyed on heating in tetrahydrofuran or dioxane.[3]

OTHER REACTIONS Blue color in alkaline solution; deep blue solution in H_2SO_4, becoming red-violet on addition of boric acid; red solution in acetone, changing to violet-blue with red fluorescence on heating with boric-acetic anhydride.[1, 2] Cultures, made weakly acid and extracted with acetone, yield proto-actinorhodin[2] which oxidizes to actinorhodin on treatment with alkali in air [3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus in dilution of 1:100, 000 [1] .

10. ACTINORUBIN

SOURCE Streptomyces sp [1] .

NATURE Basic [1, 2] .

CRYSTAL FORM AND COLOR Round, reddish orange clusters[3] [1] .

MELTING POINT (°C) 206-214[3] (d., corr.) [1] .

STABILITY Thermostable when neutral [1] .

OTHER REACTIONS Base: positive biuret; reduces Fehling, $KMnO_4$; negative Sakaguchi, Molisch; dialyzes through cellophane; related to streptothricin.[1]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits, at 0.004-8.0 units/ml, Bacillus subtilis, B. anthracis, Micrococcus pyogenes var. aureus, Corynebacterium xerose, C. diphtheriae, E. coli, Aerobacter aerogenes, Salmonella spp, Shigella spp, Brucella abortus, Br. melitensis, Alcaligenes faecalis, Vibrio comma, Klebsiella pneumoniae, Mycobacterium tuberculosis [2, 3] . Streptococci and Diplococcus pneumoniae are resistant [2] .

In vivo. Good protection against infection with K. pneumoniae in mice treated with very low doses (14-30 μg) [2] .

ACUTE TOXICITY LD_{50} in mice, 34 mg/kg, i.p. Blood levels detectable following i.p., but not oral, doses of 3 to 4 mg. Mice surviving higher sublethal doses showed renal and liver damage.[2]

11. ACTITHIAZIC ACID
(Acidomycin, Mycobacidin)

SOURCE Streptomyces virginiae, n. sp, and S. lavendulae [3, 4] ; by synthesis [9] .

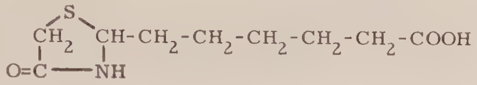
/1/ Butanol. /2/ Carmen-red, blue-fluorescing dioxane extract yields rose-colored microscopic prisms which lose their red color at 270° and decompose at 335°. /3/ Helianthate.

11. ACTITHIAZIC ACID (Concluded)

NATURE Monobasic acid [1, 4, 5] .

MOLECULAR FORMULA AND WEIGHT $C_9H_{15}NO_3S$ [1, 4-6] ; 212 (neut. equiv.); 217 (calc.).[4]

STRUCTURE



[1-3]

CRYSTAL FORM Fine needles [4-6] .

MELTING POINT (°C) 140-141 [1] ; 138-139 [4] ; 139-140 [5] ; 137 [6] .

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = -60.5^{\circ 1}$ [1] , $-57^{\circ 1}$ [4] ; $[\alpha]^{23}_{D} = -54^{\circ 2}$ [5] ; $[\alpha]^{15}_{D} = -46.2^{\circ}$ [6] .

UV ABSORPTION No characteristic spectrum [5] .

SOLUBILITY s. dilute NaOH, lower alcohols; i. water, benzene, chloroform.[1]

STABILITY Stable at room temperature over wide pH range [5] .

OTHER REACTIONS Action reversed by addition of biotin [1, 3] ; blue fluorescence in UV; negative Tollens, 2,4-dinitrophenylhydrazine, ninhydrin; Br absorbed evolving HBr in glacial acetic acid or CCl_4; permanganate quickly decolorized in aqueous solution; NH_3 evolved and slight darkening on heating a strongly alkaline solution in presence of Pb acetate; white precipitate with $HgCl_2$; no reaction with HgO.[5]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium 607 [1, 4, 6] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Myco. tuberculosis at 1.25-2.5 μg/ml. Slightly active (1000 μg/ml) against Aerobacter aerogenes, Serratia marcescens, Bacillus subtilis, Saccharomyces pastorianus, and Oospora lactis.[3, 4, 7] The amide and lower alkyl esters are also active against mycobacteria [2] . Inhibition of Myco. tuberculosis in vitro is reversed by low levels of biotin (0.008 μg/ml). Has been suggested that activity against Myco. tuberculosis may be caused by interference with biotin synthesis within this organism.[3, 7] In vitro resistance of mycobacteria to actithiazic acid not readily acquired. Only 2-fold increase in sensitivity (0.125-0.25 μg/ml), following 25 serial transfers on antibiotic-containing media.[3]

In vivo. Inactive against infections with Myco. tuberculosis in mice. Suggested that this may be from inactivation by biotin in vivo [8] . No antitumor activity against Yoshido sarcoma and Ehrlich carcinoma in mice [10] .

ACUTE TOXICITY Mice tolerated i.v. and s.c. doses of 1500 mg/kg [8] . LD_{50} in mice, 2500 mg/kg, i.p. [10] .

CHRONIC TOXICITY No side effects or histopathology noted in mice following daily s.c. doses of 1250 mg/kg daily for 4 weeks [8] .

ABSORPTION Fairly high blood levels obtained in mice following s.c. or oral administration [8] .

12. AGROCYBIN

SOURCE Agrocybe dura [1] .

NATURE Neutral or weakly acidic, acetylenic [1, 2] .

MOLECULAR FORMULA $C_8H_5O_2N$ [4] .

STRUCTURE $CH_2OHC\equiv CC\equiv CC\equiv CCONH_2$ [4] .

CRYSTAL FORM AND COLOR White crystals [1] .

MELTING POINT (°C) 130-140 (d. explosively in air) [3] ; approximately 90 (d. explosively in vacuo) [1] .

OPTICAL ACTIVITY Inactive [1] .

UV ABSORPTION MAXIMA 216, 224, 269, 286, 304, 325 $m\mu^3$ [1-3] .

SOLUBILITY s. alcohol, acetone, ether, chloroform, methyl-iso-butyl ketone; sl. s. water; i. hexane.[1]

STABILITY Thermolabile above pH 8.5 [1] .

/1/ c, 1 absolute ethanol. /2/ c, 1 methanol. /3/ 95% ethanol.

12. AGROCYBIN (Concluded)

OTHER REACTIONS Crystals turn black after exposure to air; optical density increases 10-fold during 30-minute treatment with 1% KOH in ethanol.[1, 3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus. Antiluminescence.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits, at 1 μg or less per ml, Bacillus mycoides, B. subtilis, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Mycobacterium smegmatis, Myco. phlei, M. pyogenes var. aureus. Also inhibits fungi: Aspergillus niger, Chaetomium globosum, Trichophyton mentagrophytes.[1]

ACUTE TOXICITY Hightly toxic to mice; LD_{50}, <6 mg/kg, i.v.
In man, caused a dermatitis.[1]

13. ALBIDIN

SOURCE Penicillium albidum [2] .

NATURE Red pigment [1] .

MOLECULAR FORMULA $C_5H_4O_2$ (probable) [1] .

CRYSTAL FORM AND COLOR Glistening red needles [1] .

MELTING POINT (°C) No melting at 380 [1] .

SOLUBILITY s. hot ethanol; sl. s. cold ethanol, benzene, pyridine, glacial acetic acid; 1, 4 dioxane.[1]

STABILITY Very unstable, especially above pH 3 [1, 2] .

OTHER REACTIONS Color changes with decomposition on standing: orange → brown at alkaline pH, orange → colorless → pale brown at acid pH; concentrated H_2SO_4, green; concentrated HNO_3, orange; concentrated HCl, crimson.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Inhibition of germination of Botrytis allii spores [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Fusarium graminearum, Thamnidium elegans, 0.04; B. allii, 0.2; F. caeruleum, Penicillium brevi-compactum, P. expansum, P. gladioli, 0.4; Aspergillus terreus, 0.8; A. niger, Myrothecium verrucaria, Absidia glauca, 1.6, Trichoderma viride, 3.1. Some antibacterial activity; inhibits Micrococcus pyogenes var. aureus and Salmonella typhosa at concentrations of approximately 25 μg/ml.[2]

14. ALBOMYCETIN

SOURCE Streptomyces albus [1] .

NATURE Basic [1] .

MOLECULAR FORMULA AND WEIGHT $C_{32}H_{54}O_9N$ (proposed); 596.4 (Rast). [1]

CRYSTAL FORM AND COLOR Hexagonal; colorless [1] .

MELTING POINT (°C) 166-167 [1] .

SOLUBILITY s. xylene, benzene, ethylene dichloride, methanol, ethanol, acetone, ethyl acetate, dioxane, butanol, tetralin, acid water; sl. s. ether, carbon bisulfide; i. distilled water, petroleum ether.[1]

STABILITY Thermostable at pH 2-9, 10 minutes. At 100°C for 20 minutes: 20% loss at pH 2, 50% at pH 8, no loss at pH 5.[1]

OTHER REACTIONS Precipitated by ammonium reineckate and picric acid, but not by flavianic acid and methyl orange; positive Fehling, Tollens; cherry color with Elson-Morgan; negative $FeCl_3$, Molisch, Millon, Sakaguchi, pentose with phloroglucinol. Infrared: 2.89, 3.1-4.0, 5.74, 5.90, 6.14, 7.47, 7.68, 7.79, 7.89, 8.44, 8.61, 9.01, 9.23, 9.42, 9.88, 10.3, 10.59, 10.97, 11.21, 12.08 μ.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis PCI 219[1] [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Corynebacterium diphtheriae, 0.1; Streptococcus viridans, 0.4;

/1/ More active at alkaline pH.

14. ALBOMYCETIN (Concluded)

Micrococcus citreus, B. agri, 0.8; B. anthracis, B. subtilis, Gaffkya tetragena, 1.6; Diplococcus pneumoniae, 3.1; M. pyogenes var. aureus, 3.1-6.3; Str. pyogenes, Clostridium histolyticum, 6.3; Cl. perfringens, Cl. sporogenes, 12.5; Escherichia coli, Pseudomonas aeruginosa, Proteus vulgaris, 800. Leptospira icterohemorrhagiae inhibited by 0.4 μg/ml. Fungi: Trichophyton mentagrophytes, Aspergillus niger, Saccharomyces cerevisiae, Candida albicans not sensitive to 500 μg/ml. No activity against E. coli bacteriophage C or against viruses of influenza A or Japanese B encephalitis.[1]

In vivo. Doses of 62 mg/kg, i.p., protected mice infected with Borrelia duttoni [1] .

TOXICITY LD_{50} in mice, 166 mg/kg, i.v.; approximately 332 mg/kg, i.p.; 58 mg/kg, intracerebral. LD_0, 250 mg/kg, i.p.[1]

15. ALBOMYCIN

SOURCE Streptomyces subtropicus, n. sp [1, 2] .

NATURE Basic; cyclic polypeptide containing Fe.[1, 2]

MOLECULAR WEIGHT >1300 [1, 2] .

FORM AND COLOR Sulfate: amorphous red powder [1, 2] .

UV ABSORPTION MAXIMA Approximately 290, 420 mμ [1, 2] .

SOLUBILITY s. water; sl. s. methanol; i. other organic solvents [1, 2] .

OTHER REACTIONS About 4% of pure substance by weight is Fe; removal of Fe by treatment with acetone, with mineral acids or hydroxyquinoline, gives color loss and decline in antibiotic activity, but addition of $FeCl_3$ restores both; negative Sakaguchi, Millon, Pauly, Molisch, Seliwanoff, orcinol, phloroglucinol, ninhydrin; contains ornithine, serine, glutamic acid, alanine, glycine, proline, plus one unidentified amino acid.[1, 2]

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive and Gram-negative bacteria. Inhibits Escherichia coli and Micrococcus pyogenes var. aureus at 0.0014-0.14 μg/ml.[3] Strains of the latter which are resistant to penicillin, streptomycin, erythromycin, and the tetracycline antibiotics, are sensitive to albomycin. Aerobacter aerogenes, Klebsiella pneumoniae, Shigella dysenteriae, Diplococcus pneumoniae, Bacillus subtilis, Sarcina subflava, and some strains of Streptococcus pyogenes, are also sensitive; Neisseria meningitidis and Hemophilus pertussis inhibited by higher concentrations. Listeria sp, B. mycoides, and Mycobacterium tuberculosis not sensitive.

Growth inhibition occurred only under aerobic conditions. Activity reduced in presence of blood serum because of a partial, but reversible, binding by serum protein. The antimicrobial activity is "masked" in vitro, but is demonstrable in vivo by mouse protection tests.[2]

In vivo. Described as more active, on a weight basis, than penicillin against D. pneumoniae and Spirochaeta sogdianum. Single s.c. doses of 750,000 units/kg[1] protected mice against D. pneumoniae; 150,000 units daily by the same route cleared guinea pigs of S. sogdianum. A single s.c. dose of 25,000-100,000 units/kg protected mice against K. pneumoniae. The antibiotic also protected mice against M. pyogenes var. aureus, Str. pyogenes, and Sh. dysenteriae, but was ineffective against Listeria sp, Salmonella sp, Myco. tuberculosis and rickettsiae.[2]

CLINICAL Good clinical responses following treatment of various pathogenic cocci infections (including those caused by penicillin-resistant strains) and in septic complications of dysentery and measles. Intrathecal injection of 100,000-200,000 units in children effectively controlled meningitis caused by penicillin-resistant strains of D. pneumoniae; these doses were well tolerated. In adults, 3 million units b.i.d., administered i.m. for 7-12 days, effectively treated relapsing fever caused by Spirochaeta sogdianum. Good results have also been reported in peritonitis and other surgical infections, prostatitis, and in urethritis from penicillin-resistant N. gonorrhoeae [2] .

PHARMACOLOGY The very low toxicity resembles that of penicillin. In mice, the highest levels tested (50 million units/kg), i.v. and s.c., were well tolerated. The antibiotic was also well tolerated as high doses in rabbits, cats, and, unlike penicillin, in guinea pigs. I.v. injections of large doses had no effect on the heart rate, blood pressure or respiration in animals. No histopathology observed in animals given large parenteral doses daily for 30-day periods. No side effects in man treated with daily doses of 6 million units for variable periods. Following s.c. injections in rabbits of 100,000 units/kg, blood concentrations of 240 units/ml were produced in 30 minutes, decreasing to 150 units in 4 hours and 100 units at the end of 24 hours, with about 70-80% of the total dose not bound by serum proteins excreted in the urine for 6-8 hours after administration. The protein-bound fraction was slowly excreted for 2-3 days. Wide distribution demonstrated in the various organs and tissues, with no penetration into the cerebrospinal fluid.[2]

16. ALTERNARIC ACID

SOURCE Alternaria solani [2] .

/1/ One unit equivalent to approximately 0.02 Oxford unit of penicillin [2] .

16. ALTERNARIC ACID (Concluded)

NATURE Unsaturated dibasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_{21}H_{30}O_8$; 408 (Rast); 410 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless, thin rectangular plates or elongated prisms [1] .

MELTING POINT (°C) 138 [1] .

OPTICAL ACTIVITY Inactive [1] .

UV ABSORPTION MAXIMUM 273 mμ [1] .

SOLUBILITY s. ethanol, methanol, pyridine, chloroform, benzene, ether, carbon tetrachloride; sl. s. cold water; i. petroleum ether.[1]

STABILITY Thermostable [1] .

OTHER REACTIONS Positive hydroxamic, $FeCl_3$; no reduction of Fehling, Schiff; reduced warm ammoniacal $AgNO_3$; decolorized Br water or $KMnO_4$ in acetone.[1]

QUANTITATIVE DETERMINATION Microbiological: Stunting of germ tubes of Botrytis allii or Myrothecium verrucaria [1] .

BIOLOGICAL ACTIVITY In vitro. Antifungal activity (plant pathogens). Inhibits (μg/ml) spore germination of Absidia glauca and M. verrucaria at concentrations of 0.1-1.0; B. allii at 10.[2] No antibacterial activity [3] .

TOXICITY Toxic to radish, cabbage, carrot and tomato seedlings in concentrations of 1-10 μg/ml [1] . May be the chemical agent which is directly responsible for the disease effects of early blight of potatoes [4] . A crystalline toxin isolated from Alternaria solani filtrates, apparently identical with alternaric acid, produced wilting, epinasty and necrosis in tomato cuttings within a few hours, in dilutions as high as 1:50,000,000 [5] .

17. ALTERNARINE

SOURCE Alternaria solani [1] .

CRYSTAL FORM AND COLOR White needles [1] .

MELTING POINT (°C) 230 [1] .

BIOLOGICAL ACTIVITY In vitro. Active against a number of bacteria and fungi including Pseudomonas medicaginis, Ps. mori, Xanthomonas phaseoli, X. malvacearum, X. campestris, Agrobacterium tumefaciens, Penicillium claviforme, P. chrysogenum and Botrytis allii. Also active against Micrococcus pyogenes var. aureus, Bacillus mesentericus, B. alvei, B. mycoides, Sarcina lutea, Streptococcus pyogenes, Proteus vulgaris, Escherichia coli, Mycobacterium sp and Myco. phlei.[1]

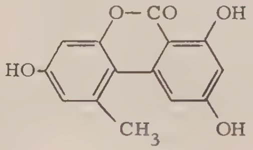
18. ALTERNARIOL

SOURCE Alternaria tenuis [1] .

NATURE Substituted dibenzo-α-pyrone [1] .

MOLECULAR FORMULA $C_{14}H_{10}O_5$ [1] .

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 350 (d.) [1] .

SOLUBILITY s. cold aqueous Na_2CO_3 or NaOH, ethanol, cold concentrated H_2SO_4, methanol, acetone, ether; i. aqueous $NaHCO_3$, benzene, petroleum ether.[1]

18. ALTERNARIOL (Concluded)

OTHER REACTIONS Sublimes without decomposing at 250°C in high vacuum; yellow-green in alkaline solution, becoming orange-red overnight; ethanolic solution gives intense purple color with ethanolic $FeCl_3$; reduces Fehling; bright cherry-red color in aqueous layer when boiled in aqueous NaOH with an equivalent volume of $CHCl_3$; yellow solution with strong blue-green fluorescence in cold concentrated H_2SO_4; no precipitation with Brady.

Alternariol methyl ether ($C_{15}H_{12}O_5$), MP 267°C (d.), is formed concurrently in fermentation; sublimes at 180-200°C in high vacuum; no optical activity; other properties very similar to alternariol. Demethylation, by heating at 140°C with concentrated HI, yields alternariol almost quantitatively.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus in dilution of 1:40,000; Escherichia coli, 1:20,000 [1] .

19. ALVEIN

SOURCE Bacillus alvei [1] .

NATURE Probably strong basic polypeptide [1] .

SOLUBILITY Base: s. ethanol, butanol; decreasing solubility above pH 7 in water. HCl: s. ethanol, water; i. acetone, chloroform, ether. [1]

STABILITY Thermostable at acid pH; less so at alkaline. [1]

OTHER REACTIONS Positive reaction for arginine, negative for tyrosine and tryptophan; positive ninhydrin after hydrolysis; presence of other amino acids indicated; inactivated by trypsin.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Mycobacterium tuberculosis in dilution of 1:100,000; Myco. phlei, 1:32,000,000; Bacillus anthracis, M. pyogenes var. aureus, 1:512,000; Streptococcus pyogenes, Corynebacterium diphtheriae, 1:128,000.[1]

TOXICITY Hemolyzes red blood cells [1] .

20. AMAROMYCIN

SOURCE Streptomyces flavochromogenes [1] .

NATURE Basic [1] .

MOLECULAR FORMULA $C_{25}H_{39}O_7N$ (proposed) [1] .

CRYSTAL FORM AND COLOR White prisms [1] .

MELTING POINT (°C) 164.5-165 [1] .

OPTICAL ACTIVITY $[\alpha]^{25}_{D}$ = + 6.19°[1] [1] .

UV ABSORPTION MAXIMUM 220 mμ[2] [1] .

SOLUBILITY s. ether, chloroform, methanol, benzene, toluene, ethyl acetate, butanol, carbon tetrachloride, ethanol, warm carbon disulfide; sl. s. cold carbon disulfide, petroleum ether, water. HCl: s. water.[1]

OTHER REACTIONS Free base analysis: C, 63.66; H, 8.73; N, 3.0. Infrared: 2.9, 3.4, 5.7, 6.10, 6.85, 7.2, 7.45, 7.85, 8.38, 8.60, 9.0, 9.25, 10.15, 10.60, 11.3 μ. Bitter taste; yellow color when concentrated H_2SO_4 is added to aqueous solution; positive Fehling, Tollens; negative $FeCl_3$, Schiff, Sakaguchi, xanthoproteic, biuret, ninhydrin, Molisch; precipitated from aqueous solution by picric acid, reinecke salt.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis PCI 219[3] [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Streptococcus pyogenes, B. agri, 0.2; Hemophilus pertussis, 0.4-50; Sarcina lutea, 0.05; Diplococcus pneumoniae, 0.78-1.56; Corynebacterium diphtheriae, 0.78; Micrococcus pyogenes var. aureus, 0.78-3.2; B. subtilis, 3.2; Brucella abortus, 1.56; Br. melitensis, Br. suis, 6.25; Proteus vulgaris, 12.5; Mycobacterium avium, Myco. phlei, 25; Myco. smegmatis, Saccharomyces cerevisiae, 50. Myco. tuberculosis, Escherichia coli, Vibrio comma, Shigella dysenteriae, Salmonella enteritidis, Nocardia asteroides, Candida albicans and Trichophyton mentagrophytes not sensitive to 50 μg/ml.[1]

ACUTE TOXICITY I.v. doses of 150-232 mg/kg toxic to mice [1] .

/1/ 1% in ethanol. /2/ With broad peak. /3/ Increased zones on alkaline pH agar.

21. AMICETIN

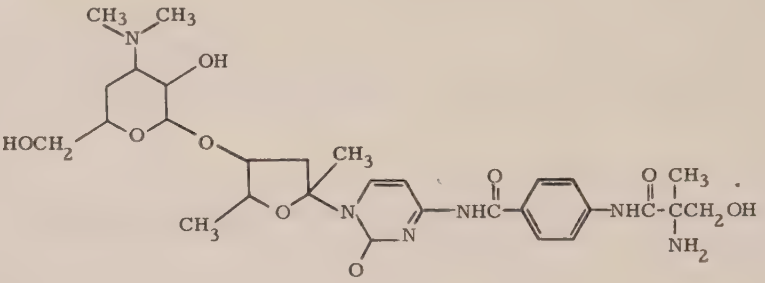
(Allomycin, Sacromycin)

SOURCE Streptomyces fasciculatus [1] ; S. sindenensis [9] ; S. vinaceus-drappus [10] .

NATURE Amphoteric [4] .

MOLECULAR FORMULA AND WEIGHT Free base: $C_{29}H_{44}N_6O_9$ [1-4] ; 620.7 (calc.) [4] .

STRUCTURE Partial:



[7]

CRYSTAL FORM AND COLOR Colorless needles [6] .

MELTING POINT (°C) Free base: 160-165; 165-169 [1-4, 6] . Granular form: 243-245 [1-4] .

OPTICAL ACTIVITY $[\alpha]_D^{24}$ = +116.5°[1] [3] ; $[\alpha]_D^{16}$ = +107.7° ± 4[1] [6] .

UV ABSORPTION MAXIMA 305[2], 316[3], 302[4], 322[5], 318 mμ[6] [1-3] .

SOLUBILITY s. water[7], aqueous mineral acid and alkali, n-butanol saturated with water; sl. s. organic solvents. [3, 4, 6]

STABILITY Most stable at pH 5; especially unstable above 8.5.[4]

OTHER REACTIONS pK 7 and 10.4; apparently 2 antibiotics in beers.[1-4] Positive ninhydrin; negative biuret, Sakaguchi, Fehling, Ag mirror, $FeCl_3$.[6]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus; Mycobacterium avium. [2, 3]

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria, particularly mycobacteria. Inhibits (μg/ml) Myco. tuberculosis, 0.5-1.0; Myco. avium, Myco. smegmatis, Leuconostoc citrovorum, Corynebacterium diphtheriae, 1.6; Myco. phlei, 0.2; M. pyogenes var. aureus, 2.0; Bacillus subtilis, 4.0; M. flavus, 0.4; Klebsiella pneumoniae and Escherichia coli, >20. [1, 2] The following sensitivity levels (μg/ml) appear in another report: C. diphtheriae, Gaffkya tetragena, 0.4; M. citreus, Clostridium tetani, 0.8; B. subtilis, Hemophilus pertussis, Salmonella enteritidis, Vibrio comma, Myco. tuberculosis var. hominis (including streptomycin-resistant strains), 1.6; M. pyogenes var. aureus, 1.6-3.2; Myco. avium, 3.2; B. anthracis, Streptococcus pyogenes, Cl. perfringens, Cl. botulinum, 6.3; Str. mitis, Diplococcus pneumoniae, 12.5; B. agri, 50; Shigella dysenteriae, Proteus vulgaris, 100. Resistant to 100 μg/ml: Salmonella typhosa, S. paratyphi, S. schottmuelleri, Sh. boydii, Sh. sonnei, Pseudomonas aeruginosa, yeasts and filamentous fungi.[6] Antibacterial activity antagonized by a number of antifungal and antiprotozoal antibiotics, including trichomycin, eurocidin, aureofacin, and seligocidin, but not by antibacterial agents (chlortetracycline, chloramphenicol, dextromycin, acidomycin, streptomycin). Activity was not impaired by a variety of amino acids, pyrimidine compounds and vitamins.[8]

In vivo. Some protection against Myco. tuberculosis in mice [1] . Activity against one strain of mouse leukemia following multiple doses of 200 mg/kg, i.p., or 2000 mg/kg, oral [5] .

ACUTE TOXICITY LD_{50} in mice, 90 mg/kg, i.v.; 600-700 mg/kg, s.c.[8] Toxic for guinea pigs. LD_{50} in rats, 200 mg/kg, i.v.; 600 mg/kg, s.c.[2] In another report, mice tolerated doses of 100 mg/kg, i.v.; 400 mg/kg, i.p.; 500 mg/kg, s.c.; and 2000 mg/kg, orally. Daily intramuscular doses of 200 mg/kg for 2 weeks were well tolerated. [6]

RESISTANCE Strains of B. megatherium readily developed a high degree of resistance [7] . A strain of M. pyogenes var. aureus developed 150-fold resistance after 9 passages in the antibiotic. The resistance development pattern resembled that characteristic of streptomycin.[6]

/1/ c, 0.5 in 0.1 N HCl. /2/ Neutral aqueous solution. /3/ 0.1 N HCl. /4/ HCl at pH 2.5. /5/ 0.1 N NaOH. /6/ NaOH at pH 11.4. /7/ 1-2 mg/ml. /8/ Citrate complex.

21. AMICETIN (Concluded)

MODE OF ACTION Essentially bacteriostatic; high concentration (500 μg/ml) was bactericidal to M. pyogenes var. aureus in 12 hours [6] .

22. ᴅ-4-AMINO-3-ISOXAZOLIDONE

(PA-94)

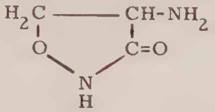
Trademarks for ᴅ-4-amino-3-isoxazolidone are Cycloserine (Commercial Solvents Corporation), Seromycin (Eli Lilly & Company), and Oxamycin (Merck & Co., Inc.).

SOURCE Streptomyces garyphalus, n. sp [1] , S. orchidaceus, n. sp [2] , S. lavendulae [9] , and by synthesis [10] .

NATURE Weakly acidic [2] ; amphoteric [8, 9] .

MOLECULAR FORMULA AND WEIGHT $C_3H_6N_2O_2$ [2, 3] ; 102 (calc.) [5] ; 101 (cryo.) [4] ; 101-102 (equiv. wt., titr.) [4] ; 104 (equiv. wt., pot. titr.) [2] ; 110-130 (Rast) [8] .

STRUCTURE



[2-5]

CRYSTAL FORM AND COLOR Colorless crystals [4] ; fine white needles^1 [5] .

MELTING POINT (°C) 154-155 [4] ; 156 [2] ; 153 [8] ; 140-150 (d.) [9] .

OPTICAL ACTIVITY $[\alpha]_{\mathrm{D}}^{25} = +116^{\circ 2}$ [4] , $+112^{\circ 3}$ [5] , $+64^{\circ 4}$ [9] ; $[\alpha]_{\mathrm{D}}^{24} = +121^{\circ 5}$ [8] .

UV ABSORPTION MAXIMUM 226 mμ [4] .

SOLUBILITY v.s. water; s. methanol; sl. s. most organic solvents [8, 9] .

STABILITY Stable to alkali [4] ; thermostable [9] .

OTHER REACTIONS Positive ninhydrin; one-half of the N exists as a primary amino group; ᴅ(-)serine and hydroxylamine isolated from hydrolysates; Ag salt, $C_3H_5N_2O_2$ Ag, prepared; Ca salt, MP 215-220° (d.), $[\alpha]_{\mathrm{D}}^{25} = 73.7°$ (c, 1 water), more stable than ionic form; pKa 4.4, 7.3-7.4; dimerizes in solution. Infrared: No band in region of 2.5-3.4 μ; broad hydrogen bonded NH-OH stretching frequencies in the region 3.6-4.7 μ; maxima at 6.12, 6.20, 6.28, 6.43, 6.52 μ.[2, 4, 5] Yellow-brown with ninhydrin, red with $FeCl_3$; poorly adsorbed except on strong cation and anion exchange resins; addition of p-toluenesulfonic, or other strong organic acids, facilitates extraction with higher alcohols.[8, 9]

QUANTITATIVE DETERMINATION Colorimetric [14] . Microbiological: Micrococcus pyogenes var. aureus [1] ; Bacillus subtilis, Escherichia coli [9] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis (including strains resistant to isoniazid, pyrazinamide, and p-aminosalicylic acid), 2.5-10; Corynebacterium diphtheriae, M. pyogenes var. aureus, 6.25-50; C. pseudodiphtheriticum, 6.25-<62.5; C. renale, C. xerose, 12.5; Myco. phlei, 20-125; Klebsiella pneumoniae, 25-500; Streptococcus (group D) 50-100; C. pyogenes, Pasteurella multocida, Str. pyogenes, Str. viridans, Diplococcus pneumoniae, Salmonella gallinarum, S. pullorum, S. schottmuelleri, Shigella dysenteriae, Sh. paradysenteriae, Sh. sonnei, E. coli, M. conglomeratus, Neisseria meningitidis, 100; Pseudomonas aeruginosa, 100-1000; Proteus spp, 125-500; Str. faecalis, 200; Alcaligenes faecalis, S. typhimurium, 400. Fungi: Candida albicans, Cryptococcus neoformans, Blastomyces dermatitidis, Trichophyton mentagrophytes, Microsporum audouini, Epidermophyton floccosum not inhibited by 100 μg/ml [1-3, 6] . Combinations of this antibiotic with streptomycin, penicillin, or oxytetracycline show synergistic effect against Gram-positive (including Myco. tuberculosis) and Gram-negative bacteria in vitro and in vivo [1, 3] .

In vivo. Relatively inactive against Myco. tuberculosis infection in mice treated with oral or s.c. doses of 10 mg/da, but when combined with dihydrostreptomycin the therapeutic effect is greater than that of the latter alone [3] . Good protection in mice infected with M. pyogenes var. aureus and K. pneumoniae following s.c. or oral doses of 1.1-2.5 mg, or S. schottmuelleri after mouse doses of 5.2 mg. Also effective in mouse infections with E. coli, Ps. aeruginosa, Str. pyogenes, D. pneumoniae, and penicillin-resistant strains of M. pyogenes var. aureus. In chick embryos, 1-5 mg suppressed Rickettsia mooseri (murine typhus); on a weight basis the antibiotic was approximately 1/10 as active as chlortetracycline. In mice, single s.c. or oral doses of 330 mg/kg gave protection against R. mooseri, and on a weight basis was approximately 1/50 as active as chlortetracycline. Slight suppression of feline pneumonitis virus in embryonated eggs; no activity against viruses of SK encephalomyelitis and swine influenza. In mouse infections with Borrelia novyi, the organisms were completely eliminated following treatment,

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/1/ From aqueous alcohol. /2/ c, 1.17 water. /3/ c, 5 in 2 N NaOH. /4/ Methanol. /5/ c, 2.53 water.

22. D-4-AMINO-3-ISOXAZOLIDONE (Concluded)

but the antibiotic was only approximately 1/10 as active as penicillin on a weight basis. Slight activity against Entamoeba histolytica in rats and Plasmodium gallinaceum in chicks. No effect on cecal coccidiosis (Eimeria tenella) in chicks, enterohepatitis (Histomonas meleagridis) in turkeys, or experimental trypanosomiasis (Trypanosoma brucei) in mice. No anthelmintic activity against Schistosoma mansoni or mouse oxyurids.[3] No activity against psittacosis virus in chick embryos [15]. Little or no protection in guinea pigs with experimental tuberculosis [16].

CLINICAL Favorable responses reported in preliminary trials in advanced pulmonary tuberculosis refractory to treatment with other antitubercular agents, following oral doses of 1-1.5 g/da for 6 weeks-4 months [7, 17]. Good clinical response in urinary tract infections in which Proteus, Pseudomonas, Aerobacter aerogenes, and Escherichia coli were predominating organisms [6]; also good response in bacterial pneumonia and chronic upper respiratory infections [18, 19]. Preliminary trials showed good results in herpetiform infections [18], and in donovanosis [21]. Was ineffectual in treatment of gonorrhea and lymphogranuloma venereum [19, 20].

PHARMACOLOGY In man, side effects were rare following daily oral doses of 1-4 g; some patients showed headache, vertigo, and drowsiness during therapy; anorexia and neurological symptoms in isolated cases.[6, 7] Readily absorbed from gastrointestinal tract. Following oral doses of 0.5-1.0 g, blood levels of 6-15 μg/ml produced in 4 hours, dropping to 2-7.5 μg/ml in 24 hours; urine concentrations of 52-190 μg/ml observed in 8 hours with continuous excretion for 48 hours, but no significant levels in the feces. Very high blood concentrations observed following oral amounts of 2-3 g/da in divided doses. Preliminary studies indicate high levels obtained in cerebrospinal and pleural fluids.[6, 11] After oral doses, the concentrations in spinal fluid and in milk approximated those in plasma. The antibiotic was well distributed in the body tissues. Single oral, or intramuscular, doses penetrated the placental barrier. Following intramuscular injection of 250 mg, 26% of the administered dose was excreted into the urine during the following 24 hours at concentrations of approximately 54 μg/ml. Neurological symptoms, both excitatory and depressant, appeared in several cases of tuberculosis during treatment. Grand mal seizures, twitchings and psychoses have been observed.[17, 21-23, 25]

In mice, the LD_{50} was reported as 1810 mg/kg, i.v.; 2870 mg/kg, i.p.; 2800 mg/kg, s.c.; 5290 mg/kg, oral. LD_{50} in rats, >3000 mg/kg, s.c.; >5000 mg/kg, oral; in guinea pigs, >1000 mg/kg, s.c.; >2000 mg/kg, oral; in dogs, >2000 mg/kg, oral. High doses (50 mg/kg, i.v.) resulted in a transient depressor action in the anesthetized dog, with no significant effect on the heart or intestinal motility. The renal clearance in dogs approximated the glomerular filtration rate. Daily i.v. doses of 50-100 mg/kg in dogs over a one-year period, and multiple oral doses of 100-300 mg/kg/da in monkeys, produced no visceral or hemopoietic changes.[26] In guinea pigs treated with a single i.m. dose of 65-70 mg/kg, the average plasma level was 95 μg/ml in 1-1/2 hours, dropping to 10 μg/ml at 7 hours [27]. In monkeys, dogs, and rabbits, the antibiotic was rapidly absorbed from the stomach and intestines, with high levels in plasma, urine, lymph, amniotic fluid and fetal blood [26].

MODE OF ACTION In vitro. Activity against Myco. tuberculosis is bacteriostatic rather than bactericidal. The antibiotic does not appear to arrest immediately metabolism of Myco. tuberculosis, since exposure to 20 μg/ml had no effect on oxygen consumption during the first six hours.[24] Unlike isoniazid, there was no significant tuberculocidal effect in the presence of glucose [12]. Action against Myco. paratuberculosis is reversed by increasing concentrations of mycobactin, a growth factor prepared from Myco. phlei. Since Myco. paratuberculosis is unable to synthesize mycobactin, it appears that the antibiotic competes directly with this factor.[13]

23. AMPHOMYCIN

SOURCE Streptomyces canus [1].

NATURE Amphoteric; acidic polypeptide.[1, 3]

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = +7.5^{\circ} \pm 0.5$[1] [1, 3].

UV ABSORPTION MAXIMA Only end adsorption [1, 3].

SOLUBILITY s. water[2], lower alcohols; i. non-polar solvents.[1, 3]

STABILITY Stable in aqueous solution 1 month at pH 7, room temperature [1, 3].

OTHER REACTIONS Negative ninhydrin (positive after acid hydrolysis), Sakaguchi, Molisch, Ehrlich-Pauly; positive biuret [1, 3].

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis[3] [1, 3].

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria; no activity against Gram-negative bacteria and Candida albicans. Inhibits (μg/ml) Corynebacterium xerose, 0.25; B. anthracis, B. cereus, Lactobacillus leichmannii, 0.5; Streptococcus agalactiae, Str. dysgalactiae, 1.25; Str. pyogenes, Str. uberis, Diplococcus pneumoniae, Micrococcus pyogenes var. aureus, 2.5; B. subtilis, L. casei and Gaffkya tetragena, 5; L. acidophilus, 10.

/1/ c, 1 water pH 6. /2/ Minimum solubility at pH 3-4 [3]. /3/ ATCC 6633.

23. AMPHOMYCIN (Concluded)

Resistant, >100 μg/ml: Salmonella typhosa, Klebsiella pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, Escherichia coli, Shigella sonnei, Candida albicans.[1]

In vivo. Doses of 0.5 mg/kg, i.p., gave good protection against infections with D. pneumoniae in mice; much larger oral doses were required.[1]

ACUTE TOXICITY LD_{50} in mice, (Na salt) 178 mg/kg, i.v.; (Ca salt) 120 mg/kg, i.v. LD_{50} in dogs (Na salt), 100 mg/kg, i.v.; >500 mg/kg, oral. Single i.m. doses of 60 mg/kg tolerated by rats, rabbits, and dogs with some irritation at injection site.[2]

CHRONIC TOXICITY Mice tolerated 100 mg/kg/da, i.p., for 20 days. Repeated injections in dogs of 15-50 mg/kg/da, i.v., or 20-40 mg/kg, i.m., did not alter blood chemistry or cell counts; a slight proteinuria noted. Doses >50 mg/kg produced some renal and cardiovascular damage. Repeated daily topical applications of 1-2.5% to rabbit eye were non-irritating; higher concentrations induced mild reactions.[2] In vitro. Partial hemolysis of red blood cells [1] .

ABSORPTION Rapidly absorbed following i.m. administration in dogs and rabbits; poor absorption after oral doses. I.m. injection of 20-40 mg/kg gave very high serum concentrations which were maintained between 1-5 hours, with approximately 37% of the total dose excreted in urine within 24 hours.[2]

24. AMPHOTERICINS

SOURCE Streptomyces sp [1] .

NATURE Amphoteric [2] . Neutral equivalent, A: 915; B: 929.[1]

STRUCTURE
Amphotericin A: conjugated tetraene.
B: conjugated heptaene.[2]

OPTICAL ACTIVITY
Amphotericin A: $[\alpha]_D^{23.5} = -9.9^{\circ}$[1], $+32^{\circ}$[2].
B: $[\alpha]_D^{23.5} = -33.6^{\circ}$[1], $+333^{\circ}$[2].[2]

UV ABSORPTION MAXIMA
Amphotericin A: 291, 305, 320 mμ[3,4].
B: 364, 383, 408 mμ[3]; 363, 382, 406 mμ[4] [1] .

SOLUBILITY s. aqueous lower alcohols at pH 10.5. Amphotericin A more soluble than B in methanol-$CaCl_2$, N, N-dimethylformamide; i. anhydrous alcohols, esters, ethers, benzene, toluene, H_2O at neutral pH.[2]

STABILITY Dry solids stable for long periods at moderate temperature.
Amphotericin A: Stable at pH 6 and 7 at 30°C.
B: Undergoes decomposition at all pH values between pH 4 and 10.[2]

OTHER REACTIONS Analysis: Amphotericin A: C, 60.32; H, 8.39; N, 1.72; B: C, 60.40; H, 8.38; N, 1.62. Both negative $FeCl_3$; both positive Molisch; decolorize $KMnO_4$ or Br_2-CCl_4; yield volatile bases when treated with concentrated NaOH. Amphotericin A forms water-soluble Na salt with methanolic NaOH, B does not; A forms methanol-soluble $CaCl_2$ complex, B does not [2] .

QUANTITATIVE DETERMINATION Microbiological: Saccharomyces cerevisiae[5] [1] .

BIOLOGICAL ACTIVITY In vitro. Primarily active against yeasts and fungi.

Amphotericin A: Inhibits (μg/ml) Histoplasma capsulatum, Rhodotorula glutinis, 0.8; Candida tropicalis, C. pseudotropicalis, Rh. mucilaginosa, Sac. cerevisiae, Sporotrichum schenckii (yeast phase), Microsporum audouini, Trichophyton megnini, Epidermophyton floccosum, Phialophora verrucosa, Blastomyces brasiliensis, 1.2-1.8; C. albicans, T. rubrum, T. gallinae, Monosporium apiospermum, Cryptococcus neoformans, Fusarium bulbigenum, 2.4; Candida parakrusei, T. tonsurans, T. mentagrophytes, Aspergillus fumigatus, 3.1-3.9; Microsporum canis, Cladosporium wernecki, Fonsecaea pedrosoi, F. compactum, Geotrichum sp, 4.0-4.7; Candida parapsilosis, 5.5; Cephalosporium recifei, 5.9; Cladosporium carrioni, 6.3; Microsporum gypseum, 9.4; S. schenckii (mycelial phase), 18.8. Bacteria and Nocardia spp not sensitive to 50 μg/ml.[1]

B: Inhibits (μg/ml) S. schenckii (yeast phase), <0.07; H. capsulatum, 0.04; Cr. neoformans, Ep. floccosum, Bl. brasiliensis, 0.2; Candida albicans, Rh. glutinis, Rh. mucilaginosa, Sac. cerevisiae, 0.5-0.6; C. pseudotropicalis, C. parakrusei, Microsporum audouini, T. megnini, Monosporium apiospermum, 0.9-1.1; A. fumigatus, 1.9; T. mentagrophytes, 2.4; C. tropicalis, 3.7; T. tonsurans, 4.9; Microsporum canis, T. rubrum, T. gallinae, Fusarium bulbigenum, 14.7. The following were not sensitive to 40 μg/ml: C. parapsilosis, S. schenckii (mycelial

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/1/ 0.1 N methyl-hydroxide-HCl. /2/ Acid dimethylformamide. /3/ 70% propanol. /4/ Methanol. /5/ Squibb culture No. 1600.

24. AMPHOTERICINS (Concluded)

phase), Cephalosporium recifei, Cladosporium carrioni, C. wernecki, Fonsecaea pedrosoi, F. compactum, Phialophora verrucosa, Geotrichum sp; also Gram-positive and Gram-negative bacteria and Nocardia spp.[1]

In vivo. Amphotericin A: Median protective dose against intravenously-injected Candida albicans in mice, >17.6 mg/kg/da, s.c.; in H capsulatum infection, 20 mg/kg/da; against Cr. neoformans, 25.5 mg/kg/da.[4]

B: Daily doses of 10-25 mg/kg, i.p., or 600 mg/kg, orally, gave good protection in mice infected with Coccidioides immitis. Daily i.p. doses of 10-25 mg/kg controlled Candida albicans infection induced by the same route.[3] Median protective dose in mice, infected with C. albicans by i.v. or intracerebral routes, was <0.32 mg/kg, s.c., or 0.55 mg/kg, per os; against H. capsulatum, 10.2 mg/kg/da, s.c., for 6 days; and against Cr. neoformans, 2 daily doses of 5.1 mg/kg, s.c. Experimental skin infections with T. mentagrophytes in guinea pigs were successfully treated with 2% antibiotic ointment.[4]

PHARMACOLOGY Amphotericin A (Na salt): LD_{50} in mice, 450 mg/kg, i.p. Daily oral doses of 80 mg/kg tolerated.

B: LD_{50} in mice, 25 mg/kg, i.v.; 280 mg/kg and >1200 mg/kg, i.p. Daily doses of 100 mg/kg, i.p., and 600 mg/kg, oral, tolerated.[3, 4] Following daily oral doses of 40 mg/kg in mice, B appeared to cross the blood-brain barrier [4] .

25. ANGOLAMYCIN

SOURCE Streptomyces eurythermus, n. sp [1] .

NATURE Basic [1] .

MOLECULAR FORMULA AND WEIGHT $C_{49-50}H_{87-91}O_{18}N$ [1] . 1020 (equiv. wt. found); 992.2±14 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless crystals[1]; colorless needles[2].[1]

MELTING POINT (°C) 133-136[1]; 165-168[2] [1] .

OPTICAL ACTIVITY $[\alpha]^{21}_{D} = -64^{\circ}$[3] [1] .

UV ABSORPTION MAXIMUM 240 mμ[4] [1] .

OTHER REACTIONS Infrared: In 6μ range bands at 1715, 1686, 1623 (recip. cm); upon hydrogenation with palladium, takes up 1 mole H, and, with platinum oxide in acetic acid, 3 moles of H; very similar to carbomycin, but differs from carbomycin and erythromycin in color reactions and paper chromatography; at least 2 sugar components are obtained by acid hydrolysis, but neither is identical with desosamine ($C_8H_{17}O_3N$) [1] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis, B. megatherium [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria and protozoa. Inhibits (μg/ml) B. megatherium, 0.1-1.0; Streptococcus pyogenes, 10; Micrococcus pyogenes var. aureus (including a penicillin-resistant strain), Entamoeba histolytica, 10-100; Corynebacterium diphtheriae, 100. The following were not sensitive to 100 μg/ml: Str. mitis, Str. faecalis, Escherichia coli, Salmonella sp, Shigella sonnei, Pseudomonas aeruginosa, Klebsiella pneumoniae, Pasteurella pestis, Vibrio comma, Mycobacterium tuberculosis, Candida albicans, and C. tropicalis.[1]

In vivo. Doses of 50 mg/kg, s.c., protected mice against infection with Str. pyogenes [1] .

ACUTE TOXICITY Mice tolerated 500 mg/kg, s.c.; 1000 mg/kg s.c. doses were lethal.[1]

26. ANGUSTMYCIN

SOURCE Streptomyces hygroscopicus [2] .

NATURE Neutral or weak base [1] .

MOLECULAR FORMULA $C_{14}H_{14}O_5N_6$ or $C_{14}H_{16}O_5N_6$ (proposed)[5]; $C_{14}H_{16}O_6N_6$ or $C_{14}H_{18}O_6N_6$ (proposed)[6].[1]

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) Anhydride: 169.5 (d.). Hydrate: 128-131 (d. at 164.5).[1]

OPTICAL ACTIVITY $[\alpha]^{18}_{D} = +48.3^{\circ}$[7] [1] .

UV ABSORPTION MAXIMUM 260 mμ[8] [1] .

/1/ From benzol-ether. /2/ From diisopropyl ether. /3/ c, 1.30 chloroform. /4/ Alcohol. /5/ Crystals from ethanol (anhydride). /6/ Crystals from water (hydrate). /7/ c, 1.5 water. /8/ Methanol.

26. ANGUSTMYCIN (Concluded)

SOLUBILITY sl. s. water, ethanol, methanol, aqueous acetone; i. other organic solvents.[1]

STABILITY Thermostable at neutral and alkaline pH [1] .

OTHER REACTIONS Positive Schiff, Tollens, $FeCl_3$, ninhydrin, Sakaguchi, Molisch, indole; negative Fehling. Anhydride analysis: C, 48.27; H, 4.74; N, 24.23; hydrate: C, 45.28; H, 4.46; N, 23.85.[1]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium 607 [1] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits Myco. 607 and Myco. phlei at 25 μg/ml. Inactive against a variety of Gram-positive and Gram-negative bacteria and fungi (Bacillus subtilis, Micrococcus pyogenes var. aureus, Escherichia coli, Aspergillus sp).[1]

ACUTE TOXICITY Very low; mice tolerated doses of 2500 mg/kg, i.p.[1]

27. ANISOMYCIN

The trademark of Chas. Pfizer & Co., Inc., for anisomycin is Flagecidin.

SOURCE Streptomyces spp, including S. griseolus [1, 5] .

NATURE Basic [4, 5] .

MOLECULAR FORMULA $C_{14}H_{19}NO_4$ [1, 4, 5] .

CRYSTAL FORM AND COLOR Long white needles [1, 4, 5] .

MELTING POINT (°C) 140-141 [1, 4, 5] .

OPTICAL ACTIVITY $[\alpha]_D^{23} = -30^\circ$[1] [1, 4] ; $[\alpha]_D^{25} = -45^\circ \pm 3$[2] [1, 4, 5] .

UV ABSORPTION MAXIMA 224, 277, 283 mμ[3] [1, 4, 5] .

SOLUBILITY s. dilute aqueous acids, methanol, ethanol, acetone, dioxane, chloroform; less s. water; i. hexane, cyclohexane, carbon tetrachloride, ether.[4, 5]

STABILITY Stable at room temperature; thermolabile at acid pH.[4, 5]

OTHER REACTIONS Infrared: 3545, 3450, 3320, 2890, 2800, 1725, 1610, 1582, 1515, 1470, 1447, 1380, 1320, 1302, 1242, 1178, 1036, 962 (recip. cm) [4, 5] .

BIOLOGICAL ACTIVITY *In vitro*. Little or no antibacterial activity. Inhibits certain fungi (μg/ml): Candida albicans, 1.25-12.5; Microsporum canis, M. audouini, Histoplasma capsulatum, Cryptococcus neoformans, 100; Trichophyton sulfureum, Phialophora verrucosa, 500. The following were resistant, >500 μg/ml: Blastomyces dermatitidis, Bl. brasiliensis, Sporotrichum schenckii, Trichophyton violaceum, Hormodendrum compactum.[2, 5] Antiprotozoan activity: Inhibits Entamoeba histolytica, Trichomonas foetus, T. vaginalis at 1.5-3.1 μg/ml. [2, 5] Concentrations of 3.12 μg/ml were lethal to T. vaginalis [9] .

In vivo. Active in experimental T. foetus infection in mice. 25 mg/kg doses administered s.c. for 1-5 days cleared 70-94% of these animals of infection [3] . S.c. doses of 25-100 mg/kg effective in mice infected s.c. with T. vaginalis [10] . Daily oral doses of 25-50 mg/kg in guinea pigs protected 55-86% of the animals against E. histolytica [6] . Effective clearance of E. histolytica obtained with oral doses of 20 mg/kg in rats and 50-100 mg/kg in guinea pigs [12] .

CLINICAL Favorable results reported in human infections with T. vaginalis following topical use for several days of 1 mg tablets or powder containing 1 mg antibiotic per g powder base. No local irritation resulted from intravaginal therapy.[7, 8]

ACUTE TOXICITY LD_{50} in mice, 140 mg/kg, i.v.; 400 mg/kg, i.p.; 600 mg/kg, s.c.; 148 mg/kg, oral. LD_{50} in rats, 167 mg/kg, i.v.; 345 mg/kg, i.p.; 230 mg/kg, s.c.; 72 mg/kg, oral. LD_{50} in guinea pigs, >300 mg/kg, i.m.; >400 mg/kg, oral. Oral LD_{50} in rabbits, >200 mg/kg. In cats and dogs, parenteral or oral doses as low as 0.1 mg/kg induced emesis. Dogs tolerated 100 mg/kg, i.v. or i.m.[11]

CHRONIC TOXICITY Rats fed on diet containing 50 ppm for periods of 33 weeks showed no ill effects or histopathologic changes. Daily oral doses of 1-64 mg/kg over periods of more than 6 months were well tolerated in monkeys, with occasional emesis and diarrhea in groups receiving the higher doses.[11]

MISCELLANEOUS Some molluscacidal activity; concentrations of 6.25 μg/ml lethal to snail (Australorbis

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/1/ c, 1 methanol. /2/ c, 1 chloroform. /3/ 3.34 mg in 25 ml methanol.

27. ANISOMYCIN (Concluded)

glabratus) in 48 hours.[13]

28. ANTIMYCIN A
(Virosin, Antipiricullin)

SOURCE Streptomyces sp [13] ; S. kitazawaensis, n. sp [17] .

NATURE Weakly acid [2] .

MOLECULAR FORMULA AND WEIGHT $C_{28}H_{40}O_9N_2$ (proposed) [2, 4, 5] ; 493, 506 (Rast); 548.6 (calc.).[2]

CRYSTAL FORM AND COLOR Colorless crystals [2, 4-6] .

MELTING POINT (°C) 139-140 [2] ; 149.8-150.2 [3] ; 148-149.5 [6] ; 141-142 [17] .

OPTICAL ACTIVITY $[\alpha]^{25}_{D}$ = +64.8°[1] [2, 5] , 77.2° ± 1.0[2] [17] .

UV ABSORPTION MAXIMA 230, 320 mμ [2] ; 245, 347 mμ [5] ; 225, 320 mμ [6] .

SOLUBILITY s. ether, lower alcohols, ethylene glycol, propylene glycol, amyl acetate, methyl acetate, pyridine, acetone, chloroform; sl. s. petroleum ether, benzene, toluene, carbon tetrachloride; i. water, dilute aqueous HCl, sodium carbonate or bicarbonate.[1, 2, 4-6]

STABILITY Thermolabile; stable at room temperature, less so at alkaline pH.[1, 2, 6]

OTHER REACTIONS Positive $FeCl_3$, Gibbs phenol, Folin, diazobenzene-sulfonic acid, xanthoproteic; negative Molisch, ninhydrin, anthrone, Benedict, Hopkins-Cole, Millon, biuret, Ehrlich, fuchsin aldehyde, 2, 4-dinitrophenylhydrazine, concentrated H_2SO_4; disintegration of crystals and loss of activity in aqueous NaOH forming milky suspension; non-dialyzable; yields antimycic acid ($C_{11}H_{14}O_5N_2$) and a neutral fragment on mild alkaline hydrolysis; 4 active components common to antimycin A-35 and A-102; A-35 contains a fifth.[1, 2, 4-6]

QUANTITATIVE DETERMINATION Microbiological: Glomerella cingulata, Saccharomyces cerevisiae [1, 3, 5, 17] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Colletotrichum spp, 0.8-12.5; Nigrospora sphaerica, 0.2; Phoma lingam, 0.4; Chalara quercina, 0.8; Sclerotinia fructicola, 0.4-1.6; Venturia inaequalis, 0.4-0.8; Stemphylium sarcinaeforme, 1.6.[1, 2, 7] Torula utilis sensitive to 0.1 μg/ml; Alternaria kikuchiana, G. cingulata, Gibberella saubinetii, Ceratostomella fimbriata, Sclerotinia arachidis, Colletotrichum lindemuthianum, Gloeosporium kaki, <1.0; Piricularia oryzae, <1.0-10; Cladosporium fulvum, 10. Candida albicans, Aspergillus oryzae, A. niger, Trichophyton sp, and phytopathogenic bacteria were not sensitive to 100 μg/ml. [15] Inhibits other fungi and yeasts (Sac. cerevisiae), but there is little or no activity against bacteria [1, 2, 7] . Low concentrations (0.013 μg/ml) inhibited propagation of PR-8 influenza virus, but did not destroy preformed virus. Experimental evidence suggested that the antibiotic acted by interfering with synthetic mechanisms which permit the reproduction of virus in infected tissue.[14]

TOXICITY Oral doses of 12 mg/kg in methyl laurate were tolerated in rats; 30 mg/kg were fatal.[7] LD_{50} in rats, 0.81 mg/kg, i.p. [12] . LD_{50} in mice, 0.9 mg/kg, i.v.; 7.6 mg/kg, i.p.; 21.2 mg/kg, s.c.[17]

PHYTOTOXICITY Low toxicity when tested in a wide variety of plants [6] .

UTILIZATION Was effective in control of certain Helminthosporium diseases of oats and barley [8] . Complete control of apple scab and early blight of tomato with crude and crystalline preparations [9, 13] . Has insecticidal and miticidal properties; was effective against Coleoptera and inactive against Lepidoptera. Very effective in low concentrations against Mexican bean beetle larvae. Gave good fabric protection against the black carpet beetle at 1/100 the necessary concentration of sodium aluminum silicofluoride which is widely used for protection of fabric against insects.[10] Topical application of 20 μg/ml solutions lethal to houseflies within 24 hours. Under greenhouse conditions, infection with Piricularia oryzae was prevented in rice plants when solutions containing 18 μg/ml were sprayed on the leaves.[15]

MODE OF ACTION As a metabolic inhibitor it resembles sodium malonate in its capacity to inhibit the renal tubular excretion of p-aminohippurate in rats [16] . Acts as a pseudo-irreversible inhibitor of succinoxidase. This was demonstrated both in vitro and in vivo.[11, 12]

29. ARGOMYCIN

SOURCE Streptomyces griseolus [1] .

/1/ c, 10 chloroform. /2/ c, 3.57 chloroform.

29. ARGOMYCIN (Concluded)

MOLECULAR FORMULA AND WEIGHT $C_{25}H_{43}O_7N$ [1] .

MELTING POINT (°C) 164-164.5 [1] .

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = +8.2^{\circ}$[1] [1] .

SOLUBILITY sl. s. carbon disulfide [1] .

OTHER REACTIONS Infrared: Includes bands at 7.38, 7.65, 7.98, 8.2, 9.8, 9.95, 10.48 μ [1] .

BIOLOGICAL ACTIVITY No antitumor activity against Yoshida sarcoma and Ehrlich carcinoma in mice [2] .

TOXICITY LD_{50} in mice, 172 mg/kg, i.v.[2]

30. ASCOSIN

SOURCE Streptomyces canescus [1] .

NATURE Probably a polyene [2, 5] .

UV ABSORPTION MAXIMA 234, 288, 340, 357, 376, 398 mμ[2] [5] .

SOLUBILITY Crude preparations: s. aqueous pyridine and other N-containing heterocyclic solvents; sl. s. dry pyridine, most other organic solvents, water.[1, 5]

STABILITY Thermo-, acid, and alkali labile [1] .

OTHER REACTIONS Negative Molisch, Tollens, Ehrlich, $FeCl_3$, ninhydrin, Benedict, Sakaguchi; activity antagonized by unsaturated fatty acids, Tween 80, and less by yeast, liver extracts; some resemblance to fungicidin.[1, 2] Soluble in but inactivated by phosphoric acid, dipropyl hydrogen phosphate, dibutyl hydrogen phosphate and aromatic sulfonic acids; aqueous brucine yields an amorphous precipitate while methanolic brucine yields no precipitate; intense, unstable blue color when methanolic solution of ascosin is added to 35% or more concentration of phosphoric acid in presence of air; green color with HCl. Infrared: Includes bands at 3.0, 6.4, 8.7, 9.5, 10.1, 12.0 13.2 μ.[5]

QUANTITATIVE DETERMINATION Microbiological: Saccharomyces cerevisiae [1, 5] .

BIOLOGICAL ACTIVITY In vitro. Inhibits yeasts and filamentous fungi (μg/ml): Candida albicans, 0.2; C. krusei, Torula utilis, 0.4; Willia sp, 0.8; Aspergillus niger, Sac. cerevisiae, 1.6; Absidia orchidis, Botrytis sp, 6.2 μg; Trichophyton interdigitale, 25 μg; Mucor pusilis, 50 μg/ml.[6] Also inhibits Mycoderma, Cryptococcus, Histoplasma capsulatum, Penicillium spinulosum, Rhizopus nigricans. No activity against bacteria.[1]

In vivo. Some protection against Cryptococcus neoformans in mice [4] . Prolonged survival time in mice infected with H. capsulatum. The i.p. therapeutic dose approached toxicity level.[3]

ACUTE TOXICITY LD_{50} in mice, 12.5 mg/kg, i.v.; 8.6 mg/kg, i.p.; 168 mg/kg, s.c.; >500 mg/kg, oral.[1]

ABSORPTION No significant blood levels obtained in rabbits following i.p. or s.c. administration. Detectable concentrations in blood of mice after i.p. administration.[1]

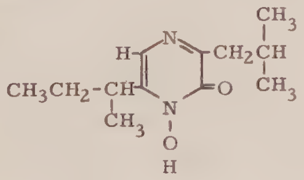
31. ASPERGILLIC ACID

SOURCE Aspergillus flavus [1] .

NATURE Monobasic acid [3] .

MOLECULAR FORMULA AND WEIGHT $C_{12}H_{20}O_2N_2$ [1-3] ; 220, 222 (found); 224.3 (calc.).[1, 2]

STRUCTURE



[7]

/1/ Ethanol. /2/ Methanol.

31. ASPERGILLIC ACID (Concluded)

CRYSTAL FORM AND COLOR Radial clusters of yellow needles [8] .

MELTING POINT ($^{\circ}$C) 97-99. HCl: 178.[2, 8]

OPTICAL ACTIVITY $[\alpha]_D^{24} = +13.4^{\circ 1}, +18.5^{\circ 2}$ [2] .

UV ABSORPTION MAXIMA 234, 328 mμ [8] .

SOLUBILITY s. hot water, excess acid, most organic solvents; i. cold water, dilute acid, petroleum ether.[1, 2]

STABILITY Very thermo-, acid and alkali stable [1, 2] .

OTHER REACTIONS Hydroxyaspergillic acid, $C_{12}H_{20}N_2O_3$, produced under some fermentation conditions; negative Millon, xanthoproteic, Molisch, biuret, ninhydrin, dinitrophenylhydrazine, Fehling, nitrous acid, $KMnO_4$, Br in CCl_4 or glacial acetic acid; vigorous reaction with aqueous Br; intense red color with $FeCl_3$ in alcohol; green precipitate with $CuSO_4$, orange with $CoCl_2$; precipitate with phosphotungstic acid; crystalline precipitate with $AgNO_3$ and $Hg(C_2H_3O_2)_2$, but not with $HgCl_2$.[1, 3, 9]

QUANTITATIVE DETERMINATION Microbiological: Several organisms, including Mycobacterium tuberculosis; antiluminescence with Photobacterium fischeri [4-6] . UV absorption spectrum [4] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Streptococcus pyogenes, 2; Diplococcus pneumoniae, 4; Klebsiella pneumoniae, 8; Micrococcus pyogenes var. aureus, 10; Salmonella enteritidis, Escherichia coli, 30; Clostridium spp, 20-60.[5] Inhibits Myco. tuberculosis in dilution of 1:10,000 [12] . Treponema pallidum immobilized in dilution of 1:2500 [10] .

In vivo. No activity in mouse infections with Str. pyogenes, D. pneumoniae, and M. pyogenes when given i.p. [5] .

ACUTE TOXICITY LD_{100} in mice, 150 mg/kg, i.p.; 250 mg/kg, oral.[1] Antibacterial activity enhanced by bismuth [11] .

32. AURANTIDIN

SOURCE Aspergillus parasiticus, or closely related sp [1] .

FORM AND COLOR Orange-red; resinous [1] .

SOLUBILITY s. most organic solvents and 50% ethanol; i. water.[1]

STABILITY Thermostable [1] .

OTHER REACTIONS Derived from medium and mycelium; has a chloramphenicol-type antimicrobial spectrum [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Escherichia coli. Also contains a factor active against Gram-positive bacteria.[1]

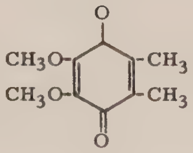
33. AURANTIOGLIOCLADIN

SOURCE Gliocladium roseum [1] ; by synthesis [3] .

NATURE p-Benzoquinone [2, 3] .

MOLECULAR FORMULA $C_{10}H_{12}O_4$ [1] .

STRUCTURE



[2, 3]

CRYSTAL FORM AND COLOR Large orange leaflets [1] .

MELTING POINT ($^{\circ}$C) 63 [1] .

/1/ c, 0.85 ethanol. /2/ c, 1.05 1 N NaOH.

33. AURANTIOGLIOCLADIN (Concluded)

UV ABSORPTION MAXIMA 275, 407 mμ [1, 2] .

OTHER REACTIONS Deep violet in concentrated H_2SO_4; reduced to a hydroquinone by SO_2 in aqueous solution; monodinitrophenylhydrazone produced with 2, 4-dinitrophenylhydrazine [1] . Closely related to spinulosin and fumigatin [2] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis; inhibition of germination of Botrytis allii spores.[1]

BIOLOGICAL ACTIVITY Low activity in vitro. Inhibits (μg/ml) B. allii at 50, Bacillus subtilis at 200, Escherichia coli at 400.[1]

34. AUREOLIC ACID

SOURCE Streptomyces sp [1] .

NATURE Weakly acidic [2] .

MOLECULAR FORMULA AND WEIGHT Mg salt: $(C_{56-60}H_{96-104}O_{29-31})_2$ Mg; approximately 1350 (neut. equiv.).[2]

CRYSTAL FORM AND COLOR Yellow crystals [2] .

OPTICAL ACTIVITY $[\alpha]_D = +68^{\circ}$[1] [2] .

SOLUBILITY s. lower alcohols, acetone; moderately s. water, ethyl acetate, ether.[2]

OTHER REACTIONS Negative Fehling, anthrone; positive tyrosine reagent, $FeCl_3$ (green); not decolorized by sodium hydrosulfite [2] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Gram-positive bacteria at 0.16-0.63 μg/ml: M. pyogenes var. aureus, Streptococcus pyogenes, Sarcina lutea, Bacillus subtilis, B. cereus. Little or no activity against Str. faecalis, mycobacteria and Gram-negative organisms. Slightly active against Trichomonas vaginalis.[1]

In vivo. Limited protection in mice infected with Str. pyogenes following i.m. doses of 1-2 mg/kg [1] .

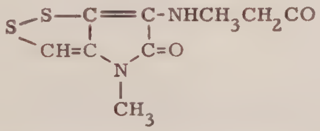
ACUTE TOXICITY Highly toxic parenterally. LD_{50} in mice, 2.5-5.0 mg/kg, i.v. I.v. doses of 0.25 mg/kg lethal in rabbits and dogs. Mice tolerated 500 mg/kg by oral route.[1]

35. AUREOTHRICIN

SOURCE Streptomyces celluloflavus, n. sp [1] .

MOLECULAR FORMULA $C_9H_{10}N_2O_2S_2$ [1] .

STRUCTURE



[4, 5]

CRYSTAL FORM AND COLOR Golden-yellow needles [1] .

MELTING POINT (°C) 256-257 (d.) [1] .

OPTICAL ACTIVITY Inactive [2] .

UV ABSORPTION MAXIMA 248, 312, 388 mμ [2] .

SOLUBILITY sl. s. organic solvents; more s. chloroform; i. water.[1]

STABILITY Very thermo- and acid stable [1] .

OTHER REACTIONS Similar to thiolutin; acid hydrolysis yields an amine, $C_6H_6N_2OS_2$, identical with one so obtained from thiolutin.[2]

/1/ c, 1 methanol.

35. AUREOTHRICIN (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis PCI 219[1] [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive and Gram-negative bacteria, and fungi. Inhibits (dilution units x 10,000) B. subtilis, 100; Vibrio comma, 75-150; Corynebacterium diphtheriae, 75; Micrococcus pyogenes var. aureus, 40-45; Streptococcus pyogenes, Diplococcus pneumoniae, Salmonella typhosa, S. paratyphi, Shigella dysenteriae, Sh. paradysenteriae, Escherichia coli, B. anthracis, 25-50; Mycobacterium phlei, 40; Myco. tuberculosis, 32; Myco. smegmatis, Salmonella schottmuelleri, 15; Myco. avium, 5; Klebsiella pneumoniae, 1. Fungi: Mucor javanicus, 32; Phytophthora sp, 64; Saccharomyces saké, 8; Aspergillus niger, 2; Botrytis cinerea, Rhizopus japonicus, 4.[1]

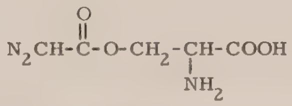
In vivo. Promoted growth of chicks when given in concentration of 15 mg/kg of ration, but diet was refused when concentrations of 45 mg/kg were used [3] . Daily i.p. doses of 30 μg had no effect on Ehrlich ascites tumor in mice [6] .

36. AZASERINE
(O-Diazoacetyl-L-serine)

SOURCE Streptomyces fragilis [1] ; by synthesis [22] .

MOLECULAR FORMULA AND WEIGHT $C_5H_7N_3O_4$; 173.13 (calc.).[3, 5]

STRUCTURE



$$N_2CH\text{-}\overset{\overset{\displaystyle O}{\parallel}}{C}\text{-}O\text{-}CH_2\text{-}\underset{\underset{\displaystyle NH_2}{|}}{C}H\text{-}COOH$$

[3, 5]

CRYSTAL FORM AND COLOR Light yellow-green needles [3, 4] .

MELTING POINT (°C) 142-162 (d. before melting) [3, 4] .

OPTICAL ACTIVITY $[\alpha]^{27.5}_{D} = -0.5^{\circ}$[2]; $[\alpha]^{28}_{D} = +9.7^{\circ}$[3].[3, 4]

UV ABSORPTION MAXIMA 250.5 mμ[4]; 252 mμ[5].[3, 4]

SOLUBILITY s. water, warm aqueous methanol, ethanol, acetone; sl. s. absolute methanol, ethanol, acetone.[3, 4]

OTHER REACTIONS Pronounced infrared peak at 4.66 μ; acidification at pH 2 results in vigorous evolution of N_2 and loss of biological activity.[3, 4]

QUANTITATIVE DETERMINATION Microbiological: Kloeckera brevis [1, 2, 4, 14] .

BIOLOGICAL ACTIVITY In vitro. Inhibits bacteria at 50 μg/ml or less: Acetobacter aceti, Bacillus cereus, B. megatherium, Clostridium spp, Escherichia coli, Hemophilus influenzae, Neisseria catarrhalis, N. meningitidis, Pasteurella multocida, Salmonella typhosa, S. schottmuelleri, Vibrio comma, Mycobacterium tuberculosis [2, 6] . Fungi inhibited at 250 μg/ml or less: species of Alternaria, Armillaria, Aspergillus, Candida, Cercospora, Helminthosporium, Nematospora, Polyporus and Poria [2, 6, 9] . Protozoa (μg/ml): Entamoeba histolytica, 250; Trichomonas foetus, 100. No activity against 3 species of trypanosomes.[6] The antibiotic is a potent mutagen for Escherichia coli [15] .

In vivo. Activity in chicks infected with Plasmodium lophurae (0.1% drug in diet). Inactive against Entamoeba histolytica in rats. Active against meningopneumonitis virus and Rickettsia prowazekii in chick embryos in doses of 0.2-1.0 mg. No activity demonstrated with viruses of influenza, yellow fever, vaccinia, St. Louis encephalitis, rabies and poliomyelitis.[6] In mice, azaserine inhibited development of a strain of mouse leukemia [7] . Retarded growth in mice of Crocker mouse sarcoma 180. Good correlation noted between this antitumor activity and the in vitro inhibition of the yeast, K. brevis.[2] Retarded growth of Murphy-Sturm lymphosarcoma and Walker carcinoma 256 in rats; also adenocarcinoma E-0771, Patterson lymphosarcoma and several ascites tumors in mice. Daily i.p. doses of 0.8-3.2 mg had a slight suppressive effect on Ehrlich ascites carcinoma in mice; higher dose levels were too toxic to evaluate [16] . Daily i.p. doses of 2-5 mg/kg in mice or rats inhibited Flexner-Jobling carcinoma, Mecca lymphosarcoma, and mammary carcinoma 755, and were ineffective against certain other experimental neoplasms [24, 25] . Tumoristatic activity observed following oral as well as parenteral dosage [26] . Other carcinomas and lymphosarcomas of mice and rats arrested with i.p. doses of 5 mg/kg, provided treatment was initiated one day later. Sarcoma 180 was the only experimental tumor inhibited by therapy started 7 days later.[13] A marked potentiation of activity against sarcoma 180 in mice was observed when combined with 6-mercaptopurine [15] . No protection in mice infected with Myco. tuberculosis [9] .

CLINICAL Trial in 56 patients with various forms of neoplastic disease, with total i.v. or oral doses of 50-200 mg

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/1/ Zones increased at acid, decreased at alkaline pH. /2/ c, 8.46 water pH 5.18. /3/ In 2 N HCl, final value preceded by constant change. /4/ pH 7. /5/ 0.1 N NaOH; little or no absorption with 0, 1 N HCl.

over periods of 5-20 days, gave rather indifferent results with brief periods of objective improvement observed in a few cases [17] .

PHARMACOLOGY S.c. doses of 50 mg/kg/da for 14 days were toxic in tuberculosis-infected mice [9] . Single parenteral doses of 100-200 mg/kg in rats induced necroses in the pancreas, liver and kidneys, within 24 hours [10] . Azaserine rapidly disappeared from the blood and was excreted in the urine within 2 hours after i.v. injection in animals. Only 1% or less of i.v. or oral dose was recovered in the urine during 24-hour period. The antibiotic appeared to be destroyed by an enzyme (probably a deaminase) present in the liver, kidneys and spleen.[11] Antimicrobial and antitumor activity were destroyed by extracts prepared from mouse liver [8] .

In man, toxic effects which appeared after 5-20 days of medication, with total i.v. or oral doses of 50-200 mg, mainly involved the digestive tract with nausea and vomiting. Redness of tongue and buccal mucosa, which occasionally became ulcerated, also were noted.[17]

PHYTOTOXICITY Repressed root growth of cucumber, barley, and flax seedlings in low concentrations (0.7-2.6 μg/ml) [12] .

MODE OF ACTION In Saccharomyces cerevisiae, the antibiotic inhibits glucose fermentation, stimulates uptake of inorganic phosphate, and is utilized by the yeast with a parallel release of serine into the culture medium. All of these actions are reversed by leucine. [27] Concentrations as low as 0.1 μg/ml in vitro caused a 50% inhibition of the biosynthesis of ribosidic derivatives of both 5-amino-imidazole and 5-amino-4-imidazole carboxamide by resting cells of mutant strains of Escherichia coli; inhibition of the latter compound was reversed by amino acids. [28] . In relatively small doses, the antibiotic affected de novo purine synthesis in ascites cell tumors by inhibiting utilization of glycine. The utilization of adenine was enhanced. A single dose caused a reduction in the mitotic index and gross damage to the tumor cells during the 12-hour period in which it was effective.[20]

MISCELLANEOUS The antibiotic appears to interfere with synthesis of aromatic amines by E. coli [18] . When injected into tumor-bearing animals prior to administration of labelled compounds, azaserine inhibits incorporation of formate and glycine into nucleic acids of sarcoma 180, adenocarcinoma E-0771, intestine and liver [19] . It induced rapid formation of greatly elongated non-septate filaments in E. coli [21] . Concentrations as low as 0.1 μg/ml in a salts-glucose medium induced formation of active bacteriophage (lambda) in the lysogenic E. coli strain K-12 [23] . Azaserine produces characteristic developmental abnormalities in chick embryos which are prevented by adenine, adenosine, hypoxanthine, and inosine, but not by guanine, xanthine, uric acid, glutamine, serine or histidine [29] .

37. AZOMYCIN

SOURCE Nocardia sp resembling N. mesenterica [2] .

NATURE 2-Nitro-imidazole [3] .

MOLECULAR FORMULA $C_3H_3N_3O_2$ [3] .

CRYSTAL FORM AND COLOR White needles [4] .

MELTING POINT (^{o}C) 283 (d.) [1] ; 281-282 (d.) [4] .

OPTICAL ACTIVITY Inactive[1] [1] .

UV ABSORPTION MAXIMA 313 mμ[2] [1] ; 314 mμ [4] .

SOLUBILITY s. methanol, ethanol, acetone, ethyl acetate, butyl acetate, alkali, dioxane; i. ether, petroleum ether, chloroform, carbon tetrachloride, benzene, acid water. [1, 4]

STABILITY 50% loss at 100^{o}C at pH 2-8 in 30 minutes [4] .

OTHER REACTIONS Analysis: C, 32.0, 31.89; H, 2.65, 2.67; N, 36.67, 36.75, 36.56.[1] Nitro group confirmed by infrared and by catalytic hydrogenation; hydrogenated product gives positive Pauly; reductive acetylation gives crystalline compound ($C_5H_7N_3O$); negative $FeCl_3$, ninhydrin, biuret, Fehling, Molisch, Millon.[3, 4]

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive and Gram-negative bacteria. Inhibits (μg/ml) Salmonella paratyphi, Shigella dysenteriae, 3; Salmonella typhosa, 5; Bacillus subtilis, 6; Micrococcus pyogenes var. aureus, Shigella paradysenteriae, 12; Mycobacterium phlei, 2; Mycobacterium sp, 50; Escherichia coli, 25. Fungi are not susceptible.[1]

In vivo. Daily i.p. doses of 0.5 mg showed slight activity against Ehrlich carcinoma in mice, with slight inhibition of ascites production but no prolongation of survival time [5] .

/1/ c, 0.5 methanol. /2/ Ethanol.

37. AZOMYCIN (Concluded)

ACUTE TOXICITY LD_{50} in mice, 80 mg/kg, i.v. [1] .

38. BACCATINE A

SOURCE   Gibberella baccata.

MOLECULAR FORMULA AND WEIGHT $C_{26}H_{48}O_6N_2$ (probable); 480 (Rast).[1]

CRYSTAL FORM AND COLOR   Colorless crystals [1] .

MELTING POINT ($^{\circ}$C)   135 [1] .

SOLUBILITY   s. ether, methanol, ethanol, other organic solvents; sl. s. water.[1]

BIOLOGICAL ACTIVITY   In vitro. Inhibits fungi (phytopathogens). Marked fungistatic activity against Leptosphaeria acuta, and Sclerotinia sclerotiorum. Weaker activity against L. culmifraga, L. culmorum, Ophiobolus herpotrichus and Wojnowicia graminis (agents of cereal foot rots). Inhibits growth of Micrococcus pyogenes var. aureus but not Escherichia coli.[1]

39. BACILIPINS

SOURCE   Bacillus subtilis [1] .

NATURE   Acids [1] .

SOLUBILITY   s. amyl acetate, benzene, chloroform, ether; sl. s. water; i. petroleum ether.[1]

STABILITY   Salts: thermolabile; stable at room temperature in solutions of pH 2-10. Acids: unstable; unstable to drying.[1]

OTHER REACTIONS   Negative Molisch, 2,4-dinitrophenylhydrazine, ammoniacal $AgNO_3$; readily catalytically hydrogenated; unaffected by serum or trypsin. Analysis: Ba salt of A: C, 42.6; H, 6.3; N, 2.5; Ba 24.6. Ba salt of B: C, 52.5; H, 6.75; N, 2.09; Ba 21.6.[1]

QUANTITATIVE DETERMINATION   Microbiological: Mycobacterium phlei, Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY   In vitro. Inhibit Myco. phlei in dilution of 1:100,000, M. pyogenes var. aureus in 1:10,000. Weaker activity against Corynebacterium diphtheriae, Bacillus anthracis, Salmonella typhosa, and Escherichia coli.[1]

40. BACILLIN

SOURCE   Bacillus subtilis [3] .

SOLUBILITY   i. organic solvents [2] .

STABILITY   Thermostable [1,2] .

OTHER REACTIONS   Inactivated by blood, some media, H_2S [1-3] .

QUANTITATIVE DETERMINATION   Microbiological: Escherichia coli [1] .

BIOLOGICAL ACTIVITY   In vitro. Inhibits (in dilution of 1:80-1:960) Streptococcus sp, Diplococcus pneumoniae, Pasteurella sp, E. coli, Salmonella typhosa, S. schottmuelleri, Micrococcus pyogenes var. aureus, Mycobacterium tuberculosis.[1]

In vivo. Inactive in mouse infections with M. pyogenes var. aureus and D. pneumoniae, following doses of 1,000 mg/kg [1] .

ACUTE TOXICITY LD_0 in mice, 1000 mg/kg, i.p. [1] .

41. BACILLOMYCIN
(Fungocin, Bacillomycin R)

SOURCE   Bacillus subtilis [1,6] .

NATURE   Polypeptide with titratable acid function [3-5] .

MOLECULAR WEIGHT   Approximately 1000 (acid equiv. wt.) [4,5] ; at least 960 [9] .

41. BACILLOMYCIN (Concluded)

CRYSTAL FORM AND COLOR Colorless, microscopic needles or rosettes [3] .

OPTICAL ACTIVITY Inactive[1] [3] .

UV ABSORPTION MAXIMA 277 mμ[2]; 296 mμ[3].[9]

SOLUBILITY s. methanol, ethanol, n-butanol, acetone, concentrated acids; i. ether, hydrocarbons, dilute acids below pH 4-4.5.[2, 3, 5]

STABILITY Thermostable [1-3] .

OTHER REACTIONS Similar to, or same as, eumycin; precipitated by concentrated ammonium sulfate; non-dialyzable through cellophane; unaffected by pepsin, trypsin; contains glutamic acid, aspartic acid, tyrosine, serine, threonine; positive biuret, xanthoproteic; negative Molisch, pK 5.5.[1-5] Analysis: C, 52.69; H, 7.20; N, 12.29; O, 27.82 (by diff.).[9]

Analysis for Amino Acids[4]

Amino acid	Molar ratio	% Bacillomycin
Asp	4.19	19.0
Thr	1.00	4.0
Ser	3.94	13.7
Glu	2.03	10.4
Tyr	1.98	12.7
		59.8

.[9]

QUANTITATIVE DETERMINATION Microbiological: Trichophyton mentagrophytes [2] .

BIOLOGICAL ACTIVITY *In vitro.* Inhibits fungi (μg/ml): Blastomyces dermatitidis, Rhizoctonia solani, Botrytis cinerea, Sclerotinia spp at 2.5-10; Histoplasma capsulatum, Bl. brasiliensis, Epidermophyton floccosum, Ep. inguinale, Microsporum audouini, M. gypseum, Monosporium apiospermum, T. rubrum, T. schoenleinii, T. violaceum, Sporotrichum schenckii, Aspergillus niger, Penicillium notatum, P. roqueforti at 25-50; Rhizopus nigricans at 50-100; T. mentagrophytes, Candida albicans at 25->100. Nocardia asteroides, Hormodendrum pedrosoi and species of Colletotrichum, Phytophthora and Pythium are resistant.[1, 5, 6] Bacteria: Klebsiella pneumoniae at 25-50 μg/ml; Clostridium perfringens, Cl. histolyticum, Corynebacterium diphtheriae and Micrococcus spp are sensitive to higher concentrations. In general, Gram-negative bacteria are resistant.[6, 7]

ACUTE TOXICITY LD_{50} in mice, 75 mg/kg, i.p. [2] . Hemolytic to red blood cells in vitro in concentration of 100 μg/ml [5] .

UTILIZATION Was effective in control of diseases of grain incited by Puccinia graminis tritici, Helminthosporium sativum and H. teres [8] .

42. BACILLOMYCIN B

SOURCE Bacillus subtilis [1] .

NATURE Polypeptide [1] .

FORM AND COLOR Yellow, amorphous substance [1] .

SOLUBILITY s. alkali, ethanol, methanol, butanol, ethyl acetate; sl. s. acetone; i. benzene, xylene, ether.[1]

STABILITY Thermostable at pH 2.6-8.2 [1] .

OTHER REACTIONS Isoelectric point, pH 4.3-4.5; no S or halogen; positive biuret, xanthoproteic, Millon, Liebermann; negative ninhydrin, $FeCl_3$, Molisch; red-brown in concentrated H_2SO_4 and red on heating; no reduction of Fehling, Tollens; non-dialyzable; contains glutamic acid, aspartic acid, tyrosine, leucine, proline.[1]

QUANTITATIVE DETERMINATION Microbiological: Aspergillus niger [1] .

BIOLOGICAL ACTIVITY *In vitro.* Inhibits Aspergillus niger and other fungi [1] .

43. BACILLOMYCIN C

NATURE Polypeptide [1] .

/1/ Alcohol. /2/ In n-butanol-water-acetic acid-95% ethanol. /3/ In alcoholic NaOH. /4/ Ion-exchange chromatography.

43. BACILLOMYCIN C (Concluded)

SOLUBILITY s. ethanol, methanol, butanol, ethyl acetate, acetone, alkali; i. benzene, toluene, ether, petroleum ether, chloroform, hydrogen sulfide, carbon tetrachloride, water.[1]

STABILITY Fairly thermostable [1] .

OTHER REACTIONS Isoelectric point, pH 4.2; positive biuret, xanthoproteic, Millon, Liebermann; negative ninhydrin, $FeCl_3$, Molisch, Fehling, Tollens; red color in hot concentrated H_2SO_4; contains glutamic acid, aspartic acid, tyrosine, leucine, valine, but no threonine, serine or proline.[1]

44. BACILYSIN

SOURCE Bacillus subtilis [1] .

NATURE Neutral peptide containing S [1] .

SOLUBILITY s. water, methanol; i. dry organic solvents except methanol [1] .

STABILITY Thermostable except at low pH [1] .

OTHER REACTIONS Not precipitated by ammonium sulfate, basic lead acetate or picric, phosphotungstic and trichloroacetic acids; negative Molisch; positive ninhydrin, Pauly; inactivated by enzymes, H_2S.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. M. pyogenes var. aureus, Corynebacterium xerose and to a lesser extent Mycobacterium phlei are sensitive. Action is mainly bactericidal. Resistance appeared to develop fairly readily.[1]

TOXICITY Mice tolerated i.v. doses of 450 mg/kg. Appeared to be inactivated in vivo since no activity was detected in urine, blood or liver 5 hours after administration of these doses in mice.[2]

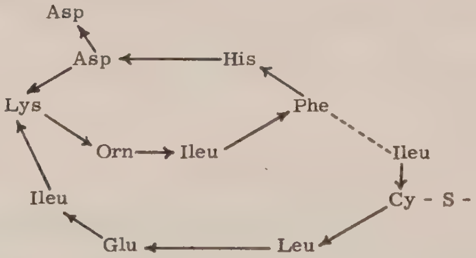
45. BACITRACINS [8, 9]
(Ayfivin)

SOURCE Bacillus subtilis, B. licheniformis [1] .

NATURE Polypeptides; weakly basic [3, 5, 6] .

MOLECULAR FORMULA AND WEIGHT Bacitracin A: $C_{66}H_{103}O_{16}N_{17}S$ (proposed) [15] ; 1470±10% (found); 1411 (calc.). [11, 17]

STRUCTURE Probable amino acid linkage of Bacitracin A:



[10, 12-14, 16]

FORM AND COLOR White, highly hygroscopic, amorphous powder [5] .

OPTICAL ACTIVITY $[\alpha]_D^{23} = +5° \pm 2.5$[1] [2] .

UV ABSORPTION MAXIMA Bacitracin A, B, D, E: 253 mμ.
C, G: 250, 268 mμ.
F_1, F_2, F_3: 253, 288, mμ. [8]

SOLUBILITY s. methanol, ethanol, water; sl. s. acetone, cyclohexanone, propanols, butanols, pyridine; i. ether, chloroform, benzene, ethyl acetate, petroleum ether.[1, 2, 6, 7]

STABILITY Relatively thermostable, especially at pH 4-5; unstable above pH 9; aqueous solution unstable after storage at room temperature.[1, 2, 6, 7]

/1/ c, 1 0.02 N HCl.

OTHER REACTIONS Precipitated by heavy metal salts, tricholoracetic, tannic, azobenzene-p-sulfonic, molybdic, and fuoric acids, concentrated NaCl, acetone, ammonium rhodanilate, Reinecke's salt; positive ninhydrin; negative FeCl$_3$, alkaline nitroprusside, Sakaguchi, Adamkiewicz, biuret, Folin-Marenzi; not inactivated by proteolytic enzymes; inactivated by Cu, H$_2$O$_2$ and partially by BAL, sodium thiosulfate.[2, 3, 5-7]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus and other Gram-positive organisms [1, 4, 7] .

BIOLOGICAL ACTIVITY In vitro. In general, active against Gram-positive bacteria with little or no activity against Gram-negative organisms. Inhibition concentrations for most strains of the following microorganisms average 0.002-5.0 units/ml[1]: Actinomyces israeli, Corynebacterium diphtheriae, C. xerose, Diplococcus pneumoniae, M. pyogenes var. aureus, Streptococcus pyogenes, Str. viridans, Str. uberis, Str. agalactiae, Sarcina lutea, Clostridium spp, Hemophilus influenzae, H. pertussis, Neisseria gonorrhoeae, Bacillus anthracis, Treponema pallidum. Strains of most of the following are generally resistant, 50 units/ml or more: Aerobacter aerogenes, Vibrio comma, Alcaligenes sp, Klebsiella pneumoniae, Pasteurella multocida, Past. pestis, Past. tularense, Proteus spp, Salmonella spp, Shigella spp, Escherichia coli, N. meningitidis, B. subtilis. Fungi are not sensitive.[1, 18, 19] In vitro activity is enhanced by cationic and decreased by anionic surface active agents [20] . Reported to enhance growth of Trichomonas foetus, hence it has been suggested that bacitracin may be a metabolite for this protozoan [21] .

In vivo. I. p. doses of 50-100 units/kg protected mice infected with clostridia, Str. pyogenes and M. pyogenes var. aureus [1, 22] . Activity against Treponema pallidum in rabbits at 1200-2000 units/kg/da [23] , and in mice infected with Borrelia duttoni [61] . In experimental meningitis induced with M. pyogenes var. aureus, good protection was obtained in dogs treated by intracisternal and i.m. routes [24] . Inhibited vaccinia virus in mice and Plasmodium lophurae in chicks dosed with 400-500 units/kg/da [25] . No activity in chicks infected with P. gallinaceum after daily i.p. doses of 400 units/kg [60] . Very effective against pinworm infestation in mice treated with a single oral dose of 100,000 units/kg [26, 27] . Daily i.p. doses of 100 mg/kg had no inhibitory effect on RC carcinoma in mice [66] .

CLINICAL In general, systemic use of bacitracin is indicated only in infections resistant to penicillin and other antibiotics. Solutions containing 500 units/ml administered by local infiltration, or as wet dressing, have been effective in therapy of superficial and deep abscesses, ulcers, infected operative wounds and in various surgical infections.[28, 46] Favorable clinical response reported in a wide variety of surgical infections following i.m. doses of 2,000-20,000 units to adults every 6-8 hours [28, 29] . Topical application of bacitracin, or of this antibiotic in combination with polymyxin or other drug in an ointment base, was highly effective in control and prophylaxis of various skin infections [30, 31] . Topical therapy useful in ocular infections [32] ; also in aural and pharyngeal infections from susceptible microorganisms [33] . Intracranial and intrathecal injection of 5,000-10,000 units has been used in purulent infections of the central nervous system and in neurosurgical wounds [37, 38] . Oral administration reported of value in chronic bacillary dysentery [34] . A high cure rate obtained following oral therapy with daily doses of approximately 60,000 units for 5-20 days in cases of acute amebic dysentery [35, 36] . Oral therapy was of value in eliminating pinworms (Enterobius vermicularis) [27] .

VETERINARY Intramammary infusions effective in bovine mastitis caused by Str. agalactiae [39] . Ointments and wet dressings for topical application gave favorable results in animals with superficial abscesses, cellulitis, suppurating surgical and traumatic wounds, and skin infections [40] . Because of little or no absorption from intestines, oral bacitracin offers a wide margin of safety for treating enteric infections in animals [41] . Favorable results have been obtained in swine enteritis [42] .

TISSUE CULTURE Low toxicity in tissue cultures. Growth inhibition of skin tissue required concentrations of 5-10 mg/ml; no inhibition of spleen tissue at 20 mg/ml.[49]

ACUTE TOXICITY LD$_{50}$ in mice, 360 mg/kg (approximately 7500 units), i.v.; 200-650 mg/kg (approximately 7,500-15,000 units), i.p.; 1300-2500 mg/kg (31,000-52,000 units), s.c. Oral doses of 3750 mg/kg (131,000 units) tolerated. In rats the LD$_{50}$ is 190 mg/kg (6700 units), i.p. Oral doses of 50,000 units/kg tolerated by rabbits; >400,000 units/kg by dogs.[41, 43, 44] I.v. lethal dose in mice for bacitracin A: 342 mg/kg; bacitracin B: 500 mg/kg; bacitracin C: 75 mg/kg.[45]

CHRONIC TOXICITY No evidence of toxicity in mice given daily oral doses of 125,000 units/kg for 30 days [41] . Prolonged daily i.m. administration of 1000-1500 units/kg well tolerated by dogs and monkeys. Damage to renal tubules noted in mice, but not in dogs, following prolonged i.m. administration.[44]

In man, nephrotoxicity, as reflected by abnormal urine findings, noted after 10 daily i.m. doses of 40,000-80,000 units [46] . Parenteral administration of 1500 units/kg on 2 successive days resulted in proteinuria, glycosuria and depressed the glomerular filtration rate for approximately 2 months [47] . Gastrointestinal disturbances have been occasionally reported. Skin sensitivity following topical use is rare, hence this advantage over penicillin [48] .

/1/ Average lots of bacitracin have a potency of approximately 40 units per mg. Further purification beyond 45 units/mg generally results in decreasing stability. More recently, however, parenteral bacitracin possesses a minimum potency of 50 units per mg, and preparations of higher potency (63-71 units/mg) have shown the same thermal stability as those of lower unitage.[65]

RESISTANCE In general, bacteria sensitive to bacitracin do not develop resistance to it in vivo with any facility, although it is possible to demonstrate this in vitro with strains of Str. pyogenes; these strains, however, rapidly lost resistance.[58]

ABSORPTION AND EXCRETION In animals after parenteral administration, antibiotic was detected in the blood, urine, feces, bile, kidney, liver, spleen, lung, heart, and skeletal muscle, with very low concentrations in the brain and cerebrospinal fluid. Highest blood concentrations occurred 1-4 hours after injection. In dogs, blood levels of 1.5-3.0 units/ml followed i.m. or s.c. doses of 3000 units/kg.[50, 51]

In man, after single i.m. dose of 50,000 units, serum concentrations of approximately 0.3 unit/ml appeared in 2 hours, declining to 0.03 unit at the 6th hour. Levels of 1-3 units/ml noted following repeated injections at 6-hour intervals. A daily urinary excretion of 10-31% of the administered dosage was observed. Following oral doses, the greater part of the total dose was recovered in the feces, and little or no measurable blood concentrations were noted.[52]

MODE OF ACTION Bactericidal as well as bacteriostatic. Reiter strain of T. pallidum inhibited by 0.004 unit in vitro, and concentrations of 0.025 unit/ml were lethal. The rate of treponemicidal activity increased with concentration up to the highest level tested (64 units/ml).[68] Bacitracin inhibits glutamic acid uptake in M. pyogenes var. aureus in a similar way to penicillin [69].

ANIMAL NUTRITION Injections of bacitracin stimulated growth of chicks although it did not alter their fecal microbial flora [53]; incorporation of 5 mg/lb ration also enhanced growth [54] and increased egg production and fertility [59]. Growth of pigs promoted when antibiotic was incorporated in diet or implanted s.c. These growth responses were generally smaller than those obtained with other antibiotics.[55, 56] Subcutaneous implantation of pellets had little or no effect on weight curve of range lambs and calves [70].

PLANT NUTRITION Plant growth was markedly stimulated by 5-10 ppm of bacitracin in sterile tissue cultures using duckweed (Lemna minor) as the test subject [57]. Growth of wheat roots in distilled water was stimulated by addition of 0.1-0.32 ppm of antibiotic [67].

MISCELLANEOUS Concentrations of 100 ppm in autoclave-sterilized media useful in laboratory for controlling bacterial contamination in cultures of sunflower-callus tissues [62]. Relatively high concentrations of bacitracin (300-500 mg per 14 lb of wheat) and certain other antibiotics were lethal to several varieties of coleopterous stored-grain insects within 30-60 days [63]. The median lethal dose, by injection, in the German cockroach, Blattella germanica, was 100-235 μg [64].

46. BIFORMYNES
(Biformin, Biforminic Acid)

SOURCE Polyporus biforminis [1].

NATURE Polyacetylene[1] [2].

UV ABSORPTION MAXIMA Biformyne 1: 259, 274, 291, 310 mμ [2, 3].
Biformyne 2: 263, 274, 290, 310 mμ[2] [3].

SOLUBILITY s. water, ether, chloroform, methyl isobutyl ketone, alcohol [1].

STABILITY Thermostable in dilute solution; unstable in concentrated aqueous solution.[1]

OTHER REACTIONS Destroyed by drying; no color with KCN; no I from cold HI; negative $FeCl_3$; biformyne 1 extractable with organic solvents, but 2 is extractable only after culture liquid is boiled; 2 can be reduced catalytically to a compound of molecular formula $C_{10}H_{20}O_2$.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1].

BIOLOGICAL ACTIVITY In vitro. Biformyne 1: Inhibits (μg/ml) Bacillus subtilis, M. pyogenes var. aureus, Mycobacterium tuberculosis, Myco. smegmatis, Myco. phlei, Escherichia coli, Klebsiella pneumoniae at 0.04-3.5; Pseudomonas aeruginosa, B. mycoides at 32-63. Inhibits fungi at 0.25-4.0 μg/ml: Stemphylium consortiale, Trichophyton mentagrophytes, Memnoniella echinata, Chaetomium globosum, Saccharomyces cerevisiae, Aspergillus niger, and Penicillium notatum. Myrothecium verrucaria required 32-63 μg/ml. Resistance by M. pyogenes var. aureus did not develop.

Biformyne 2: In vitro activity similar to that of biformyne 1 [1].

In vivo. Inactive when administered i.p. or s.c. to mice infected with M. pyogenes var. aureus and Myco. tuberculosis [1, 2].

/1/ Biformyne 1 appears to be an unsaturated 9-carbon glycol with 2 ethylenic and 2 acetylenic bonds. /2/ On treatment with alkali, both show a slow UV shift complete after 8-9 days at pH 10, 37°C; new maxima at 278, 291 mμ.

46. BIFORMYNES (Concluded)

ACUTE TOXICITY LD_{100} in mice, 18.8 mg/kg, i.v.; 37.5 mg/kg, i.p. Contact with human skin produced a severe dermatitis.[1]

47. BIOCERIN

SOURCE Bacillus cereus [1] .

SOLUBILITY s. acetone, ether, chloroform, 95% ethanol; i. water.[1]

OTHER REACTIONS Activity decreased in presence of rabbit serum [1] .

BIOLOGICAL ACTIVITY In vitro. Crude preparations inhibited (μg/ml) Micrococcus pyogenes var. aureus and var. albus at 50; Corynebacterium diphtheriae, B. anthracis, B. subtilis, Brucella suis, Escherichia coli, Aerobacter aerogenes at 500.[1]

ACUTE TOXICITY Mice tolerated i.p. doses of 1000 mg/kg [1] .

48. BORRELIDIN

SOURCE Streptomyces rochei [1] .

NATURE Acidic [1] .

MOLECULAR FORMULA $C_{28}H_{43}O_6N$ (proposed) [1] .

MELTING POINT (°C) 145-146 [1] .

OPTICAL ACTIVITY $[\alpha]^{27}_{D} = -28^{\circ}$[1] [1] .

UV ABSORPTION MAXIMUM 256 mμ [1] .

SOLUBILITY s. ether, benzene, butanol, butyl acetate, methanol, isopropanol [1] .

QUANTITATIVE DETERMINATION Microbiological: Borrelia spp, Sarcina lutea [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits S. lutea and micrococci [1] .

In vivo. Active in mice infected with B. novyi, following s.c. doses of 3.25 mg/kg. No protection afforded in experimental rabbit syphilis. Enhances activity of penicillin in vivo in experimental infections.[2]

ACUTE TOXICITY Fairly toxic to mice, rats, rabbits and chicks. LD_{50} in mice, 39 mg/kg, i.v.; 75 mg/kg, s.c.; rats, 1.8 mg/kg, s.c.[3] . Toxicity (growth stunting of rats) can be counteracted by oral doses of niacin or tryptophan [4] . Irritating to human skin [3] .

49. BOSTRYCOIDIN

SOURCE Fusarium bostrycoides [1] .

NATURE Pigment, substituted naphthaquinone [1, 2] .

MOLECULAR FORMULA AND WEIGHT $C_{18}H_{14}O_7$ (probable); 342 (calc.).[2]

CRYSTAL FORM AND COLOR Brown or red laths in clusters [2] .

MELTING POINT (°C) 243-244 [2] .

UV ABSORPTION MAXIMA 251, 320 mμ [2] .

SOLUBILITY s. strong acids, alkalies; less s. 1, 4-dioxane, benzene, ethanol, chloroform, carbon tetrachloride, acetone; i. water. [2]

OTHER REACTIONS Similar to javanicin; sublimes in vacuo; orange-red in acid, deep purple in alkaline solution. [1, 2]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium tuberculosis var. hominis [1] .

/1/ Ethanol.

49. BOSTRYCOIDIN (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Myco. tuberculosis at 10-20; Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Bacillus subtilis, Brucella abortus, Corynebacterium hoffmani, Pseudomonas aeruginosa at 2-10.[1]

PHARMACOLOGY Mice tolerated 250 mg/kg doses, i.p., s.c., or per os, for 2-21 days. Rapidly excreted in the urine following i.p. or oral administration.[1]

50. BREVIN

SOURCE Bacillus brevis [1] .

NATURE Polypeptide [1] .

SOLUBILITY sl. s. water, aqueous ethanol; i. absolute ethanol.[1]

OTHER REACTIONS Contains aspartic acid, glycine, tyrosine, serine, and an unidentified basic substance [1] .

QUANTITATIVE DETERMINATION Microbiological: Corynebacterium xerose, Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, C. xerose, C. diphtheriae, Mycobacterium tuberculosis in dilutions of 1:20,000-1:160,000. No inhibition of Streptococcus pyogenes and Gram-negative rods. [1]

51. BREVOLIN

SOURCE Bacillus brevis [1] .

FORM AND COLOR HCl: yellowish-white; amorphous [1] .

OPTICAL ACTIVITY $[\alpha]^{26}_{D} = -18.9^{\circ 1}$ [1] .

UV ABSORPTION MAXIMUM 272.5 mμ^{2} [1] .

SOLUBILITY s. water, acid methanol, methanol; sl. s. ethanol; i. acetone, ether, butanol, ethyl acetate, chloroform, benzol, petroleum ether, ligroin.[1]

OTHER REACTIONS Positive ninhydrin, biuret, Millon, Sakaguchi, xanthoproteic, Molisch, Elson-Morgan.[1]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium avium, Bacillus subtilis PCI 219 [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Myco. tuberculosis, 0.8-1.6; Myco. avium, 3-5; Myco. phlei, B. subtilis, Brucella abortus, 0.3; Micrococcus pyogenes var. aureus, Escherichia coli, 5; Shigella dysenteriae, 2.5; Salmonella typhosa, 20. No activity against Pseudomonas sp and fungi.[1]

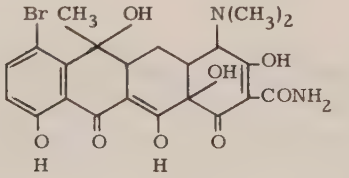
ACUTE TOXICITY LD_{50} in mice, 37.5 mg/kg, i.v.[1] .

52. BROMOTETRACYCLINE

SOURCE Chlortetracycline-producing Streptomyces strains [1] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{23}O_8N_2$ Br; 523.45 (calc.).[1]

STRUCTURE



[1]

MELTING POINT (°C) HCl: 235-240 (d.)[1] ; browns at 218 (d. at 235)[3] . Free base: 170-172 [1] .

OPTICAL ACTIVITY $[\alpha]^{20}_{D} = -196^{\circ 3}$ [1] ; $[\alpha]_{D} = -205^{\circ 4}$ [3] .

/1/ c, 1, methanol. /2/ 99% methanol. /3/ In 0.1 N HCl. /4/ 0.5% in 0.03 N aqueous HCl.

52. BROMOTETRACYCLINE (Concluded)

UV ABSORPTION MAXIMA 227, 260, 370 mμ[1]; 225, 255, 285, 345 mμ[2].[1]

SOLUBILITY In water, 1.36%[3]; in dry n-butanol, 0.038%[3].[3]

STABILITY Stable at acid pH; decreasing stability above pH 7.0 at 37°C.[2]

QUANTITATIVE DETERMINATION Hydrochloride in terms of chlortetracycline HCl: Turbidimetric: Micrococcus pyogenes var. aureus, 95%; Escherichia coli, 90%. Fluorometric: 26%. Hiscox: 45%. Spectrophotometric: 77%[4]. [3]

BIOLOGICAL ACTIVITY *In vitro*. Antibacterial spectrum resembles that of chlortetracycline. Inhibits (μg/ml) Bacillus anthracis at 0.03; Sarcina lutea, 0.15; M. pyogenes var. aureus, Streptococcus pyogenes, Str. faecalis, Klebsiella pneumoniae, B. subtilis, Clostridium perfringens, Mycobacterium phlei, Myco. ranae, 0.3; Diplococcus pneumoniae, 0.5; M. flavus, Myco. minetti, 0.6; E. coli, 1.0; Brucella abortus, 1.2; Salmonella typhosa, Bacillus cereus, 1.5; Proteus vulgaris, 2; Shigella sonnei, 3; Myco. tuberculosis var. hominis, 10; Pseudomonas aeruginosa, 20. Fungi not sensitive to 100 μg/ml.[2]

In vivo. Complete protection in mice infected with Str. pyogenes following daily oral doses of 200 mg/kg, and 30-60% protection with 50-100 mg/kg. Good protection against K. pneumoniae with 250-500 mg/kg/da, orally. High doses (500 mg/kg) gave slight protection against Myco. tuberculosis var. hominis in mice.[2]

PHARMACOLOGY LD_{50} in mice, 89 mg/kg, i.v. (HCl). Action on isolated organs and blood pressure of guinea pigs similar to that of chlortetracycline [2] .

RESISTANCE Complete cross resistance with tetracycline, chlortetracycline and oxytetracycline. No cross resistance with streptomycin and neomycin. Some E. coli strains rendered resistant to chloramphenicol showed increased resistance to bromotetracycline [2] .

MODE OF ACTION Primarily bacteriostatic; high concentrations may be bactericidal. Like other tetracyclines, bromotetracycline is active against multiplying bacterial cells.[2]

53. BRYAMYCIN

SOURCE Streptomyces hawaiiensis, n. sp [1] .

NATURE Polypeptide [1] .

MOLECULAR WEIGHT 1600-1750[5] [1] .

MELTING POINT (°C) 223-235 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]_{D}^{27} = -68.5^{\circ}$[6] [1] .

UV ABSORPTION MAXIMA 310 mμ; strong end absorption below 250 mμ[7] [1] .

SOLUBILITY s. pyridine, glacial acetic acid, 2-methylol tetrahydropyran, tetrahydrofurfuryl alcohol; less s. (20 mg/ml) chloroform, ethylene glycol, monomethyl ether, dioxane, 2 N HCl; i. water, ethanol, acetone, benzene, ethyl acetate, dimethoxyethane.[1]

OTHER REACTIONS Infrared peaks or shoulders at 3.1, 5.8, 6.04, 6.15, 6.6 (S), 8.33, 8.83, 9.48 (S), 10.73, 11.26, 12.4 and 15.0 (S) μ in a liquid petrolatum mull suspension; hydrolysis yields ninhydrin-positive hydrolysates which contain glycine, α-alanine, threonine, cystine, isoleucine, and several unidentified substances.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis[8] [1] .

BIOLOGICAL ACTIVITY Active primarily against Gram-positive bacteria.

In vitro. Inhibits (μg/ml) Streptococcus agalactiae, Str. dysgalactiae, Diplococcus pneumoniae, Lactobacillus acidophilus, Corynebacterium xerose, 0.002-0.003; Micrococcus pyogenes var. aureus, M. tetragena, L. casei, Clostridium perfringens, Cl. sporogenes, 0.02-0.03; B. anthracis, 0.05; Str. pyogenes, 0.5. The following Gram-negative bacteria were insensitive to 10 μg/ml: Salmonella typhosa, Shigella sonnei, Klebsiella pneumoniae, Escherichia coli, Proteus vulgaris, Pseudomonas aeruginosa.[1]

In vivo. Activity in mice infected with D. pneumoniae with CD_{50} of 0.004 mg/kg, i.p.; 5 mg/kg, i.m.; and 62 mg/kg by oral route. Median curative dose against Str. pyogenes infection was 0.13 mg/kg, i.p., and 30 mg/kg, i.m. [1]

/1/ In 0.1 N HCl. /2/ In 0.25 N NaOH. /3/ 25°C. /4/ 368 mμ in 0.1 N H_2SO_4. /5/ Signer. /6/ c, 1 chloroform. /7/ In 6 N H_2SO_4. /8/ ATCC 6633.

53. BRYAMYCIN (Concluded)

PHARMACOLOGY Acute toxicity in mice; LD_{50}, >750 mg/kg, i.v.; >1000 mg/kg by i.p. or oral routes.[1] Slight irritation following i.m. injection in rats and rabbits. Absorbed very slowly from intramuscular site of injection; could be recovered therefrom up to 10 days later.[1]

54. CACAOMYCETIN

SOURCE Streptomyces sp, resembling S. cacaoi [1] .

SOLUBILITY s. water, many organic solvents including carbon tetrachloride [1] .

STABILITY Stable at neutral and acid pH; unstable at alkaline pH [1] .

OTHER REACTIONS Paper chromatography indicates 4 antibiotics [1] .

BIOLOGICAL ACTIVITY In vitro. Activity against a number of saprophytic phycomycetes and ascomycetes. Inhibits (μg/ml) Monascus spp, 0.2-0.5; Aspergillus spp, 0.1-0.5; Ceratostomella fimbriata, 5; Helminthosporium oryzae, 20; Alternaria sp, 100. Trichophyton purpureum, Mucor spp, Penicillium chrysogenum, and Torula utilis are resistant, >200. Bacteria: Micrococcus pyogenes var. aureus, Bacillus subtilis, and Mycobacterium avium were sensitive to 50 μg/ml; Escherichia coli resistant, >200.[1]

55. CAMPHOMYCIN
(Canphomycin)

SOURCE Streptomyces rutgersensis var. castelarense, n. var. [1] .

NATURE Possibly a quaternary ammonium base [1] .

FORM AND COLOR White to yellowish-white powder [2] .

MELTING POINT (°C) 20-22 [2] .

UV ABSORPTION No peaks or crests; progressively diminishes from 210 to 450 mμ.[2]

OTHER REACTIONS Positive Nessler; Tollens; liberates NH_3 on action of NaOH; alcoholic solution, treated with hot concentrated HCl or H_2SO_4, turns green, then orange, and finally reddish; hot NaOH gives a red color which clears on cooling; this color disappears on oxidation with chlorine; has reductive properties.[1, 2]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, M. pyogenes var. albus, Bacillus subtilis, B. mycoides, B. anthracis, 5; Chromobacterium violaceum, 10; Escherichia coli, 50; Xanthomonas campestris, 100; Mycobacterium smegmatis, Myco. avium, Sarcina lutea, Klebsiella pneumoniae, Salmonella paratyphi, S. typhimurium, S. pullorum, Serratia marcescens, Erwinia carotovora, >100. Fungi (μg/ml): Helminthosporium sativum, Neurospora crassa, 5; Botrytis cinerea, Rhizoctonia solani, Penicillium roseum, Fusarium spp, Rhizopus nigricans, Aspergillus niger, Piricularia oryzae, Absidia glauca, Saccharomyces spp, >100.[1, 2]

In vivo. No activity against Trypanosoma equiperdum in mice treated with doses of 5 mg [2] .

TOXICITY Mice tolerated 550 mg/kg, i.v. or by oral route [1] . Concentrations of 1-10 ppm toxic to a variety of plants including maize, oat, barley, wheat, alfalfa, cabbage, tomato, carrot [2] .

56. CANDICIDINS

SOURCE Streptomyces griseus and other Streptomyces spp [1] .

UV ABSORPTION MAXIMA Candicidin A: 360, 380, 403 mμ.
B: 362, 381, 404 mμ.
C: 358, 379, 402 mμ.[1]

SOLUBILITY s. higher alcohols; i. benzene, petroleum ether, carbon tetrachloride, xylene, carbon disulfide, ethylene dichloride, ether, ethyl acetate. Only Candicidin A s. water.[1]

STABILITY Concentrated solution more stable than dilute; A and B stable at neutrality for 10 minutes at 60°C and 1 week at 4°; activity gradually lost at room temperature.[1]

OTHER REACTIONS Crude candicidin non-dialyzable [1] .

QUANTITATIVE DETERMINATION Microbiological: Candida albicans[1] [1] .

/1/ Assays on streak plates because of poor diffusion; values increase with NaCl or higher pH.

56. CANDICIDINS (Concluded)

BIOLOGICAL ACTIVITY *In vitro*. Candicidin A, B: Antifungal activity; inhibit, at 0.5-10 μg/ml, C. albicans, C. stellatoidea, C. tropicalis, C. pseudotropicalis, C. krusei, Blastomyces dermatitidis, Histoplasma capsulatum, Paracoccidioides brasiliensis, Cryptococcus neoformans, Geotrichum spp, and Hormodendrum pedrosoi. Candida parakrusei inhibited at 25-50 μg/ml. Less sensitive, 200-500 μg/ml: Coccidioides immitis, Sporotrichum schenckii, Nocardia asteroides, Trichophyton spp, Microsporum canis, M. audouini, Epidermophyton floccosum. Also inhibit species of Aspergillus, Cercospora, Botrytis, Pullularia, Trichoderma, and other phytopathogens.[1, 2]

C: Relatively inactive.

In vivo. Candicidin A, B: Protected mice against infections with Candida albicans, Bl. dermatitidis, and S. schenckii. Little or no activity against Coccidioides immitis and H. capsulatum following i.p. doses of 37.5 mg/kg/da for 10 days.[2, 4, 5]

CLINICAL Topical use of 1% solution and daily administration of suppository containing 1 g of candicidin was effective in the treatment of an isolated case of vulvovaginitis caused by Candida albicans [6] . Four patients with intertriginous moniliasis showed favorable response after topical treatment with 1% solution candicidin B. Candicidin A failed to benefit 3 cases of paronychial moniliasis [3] .

PHYTOPATHOLOGY Crude preparations decreased powdery mildew infection in young bean plants sprayed once weekly with 660 μg/ml solution. No toxic effect on bean plants at 660 μg/ml or on germination of pea seeds at 125 μg/ml.[1] A single spray application of 1:5000 of antibiotic, 3 days before inoculation of Pinto beans with Uromyces phaseoli, reduced infection by 90% [7] . Concentration of 1:16, 000 is excellent protective dip against brown rot infection of peach fruit [8] . Failed to control effectively stem rust of wheat when used as a preinoculation spray under greenhouse conditions [9] .

TOXICITY *In vitro*. In tissue cultures, concentrations of 100-200 μg/ml inhibited explants of chick embryonic heart, and 80-165 μg/ml inhibited human skin tissue [10] .

ACUTE TOXICITY Considerable variation between lots. Candicidin A: LD$_{50}$ in mice, 277 mg/kg, s.c., and 47-65 mg/kg, i.p.

B: LD$_{50}$ in mice, 159 mg/kg, s.c., and 53 mg/kg, i.p. Necrosis developed at site of s.c. injection of 25 mg/kg.[2]

57. CANDIDINS

SOURCE Streptomyces viridoflavus, n. sp [1] .

UV ABSORPTION MAXIMA Na salt: 234, 282, 345, 360, 383, 405 mμ[1] [1] .

SOLUBILITY s. water at neutral and alkaline pH. Free acid: s. ethanol, methanol, glacial acetic acid, ethylene glycol, monomethyl ether, pyridine, other basic solvents. Free acid (Na salt): i. or sl. s. ether, chloroform, acetone, benzene, non-polar solvents.[1]

OTHER REACTIONS Precipitated by dilute acetic or mineral acids; contain N, but negative ninhydrin after hydrolysis; negative Molisch, Benedict, Fehling, Tollens, Schiff, pine splint, FeCl$_3$, deep blue with H$_2$SO$_4$; decolorize Br in CHCl$_3$ and 1% KMnO$_4$; positive tests for ketones with NaHSO$_4$, semicarbazide, 2, 4-dinitrophenylhydrazine; resemble candicidin, ascosin, trichomycin. Separates by solvent extraction into 2 fractions; ethanol-soluble is candidin A, insoluble is B, but A is probably an artifact.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Candida albicans[2] [1] .

BIOLOGICAL ACTIVITY *In vitro*. Antifungal activity; inhibit C. albicans, Trichophyton mentagrophytes, Blastomyces dermatitidis, and Sporotrichum schenckii at 0.2-4.1 μg/ml. [1]

In vivo. Candidin B: Daily oral doses of 100 mg/kg resulted in complete suppression of fungi with a concomitant 1000-fold increase in bacterial fecal flora of mice [2] .

ACUTE TOXICITY LD$_{50}$ of crude preparations in mice, 7-36 mg/kg, i.p. [1] .

Candidin B: LD$_{50}$ in mice, 1.5 mg/kg, i.v.; 30 mg/kg, s.c., with necrosis at site of injection after single doses of 10-40 mg/kg.

CHRONIC TOXICITY Daily oral doses of 100 mg/kg for 6 days were well tolerated, but mice showed a reduction in spleen size [2] .

58. CANDIDULIN

SOURCE Aspergillus candidus [1] .

NATURE Neutral, non-aromatic [1] .

/1/ Aqueous solutions; free acid lacks 345 mμ peak. /2/ By streak plate.

58. CANDIDULIN (Concluded)

MOLECULAR FORMULA AND WEIGHT $C_{11}H_{15}NO_3$ (proposed); 209.13 (calc.).[1]

CRYSTAL FORM AND COLOR Long, white needles [1] .

MELTING POINT (°C) 88-89 (uncorr.) [1] .

OPTICAL ACTIVITY $[\alpha]_D^{24} = +15^\circ \pm 2$[1] [1] .

UV ABSORPTION No characteristic spectrum [1] .

SOLUBILITY s. methanol, ethanol, acetone, ether; less s. chloroform, benzene, carbon tetrachloride, water; sl. s. n-hexane.[1]

STABILITY Thermostable; alkali labile [1] .

OTHER REACTIONS Negative $FeCl_3$, ninhydrin, 2, 4-dinitrophenylhydrazine, 3, 5-dinitrobenzylchloride, xanthydrol, HgO; inactivated by Br in CCl_4.[1]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium ranae [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Myco. tuberculosis, 0.06-0.1; Myco. ranae, 0.4-2.5; Myco. smegmatis, 2.5; Mycobacterium sp, 1.25; Bacillus subtilis, Klebsiella pneumoniae, 10; Brucella abortus, 20; Escherichia coli, 160; Streptococcus hemolyticus, 160; Micrococcus pyogenes var. aureus, Sarcina lutea, 320. Fungi: Aspergillus fumigatus, 80; Penicillium puberulum, 40.[1] Inhibits Saccharomyces cerevisiae, Torula utilis, Absidia orchidis, Aspergillus niger, 6.2; Willia sp, Candida krusei, Mucor pusilis, Botrytis sp, 12.5; Trichophyton interdigitale, 50.[2] Inactivated in vitro by whole blood [1] .

In vivo. No protection against Myco. tuberculosis in mice given 12 daily s.c. injections of doses up to 200 mg/kg [1] .

ACUTE TOXICITY LD_{50} in mice, approximately 250 mg/kg, s.c. [1] .

59. CANESCIN

SOURCE Penicillium canescens (Sopp.) [1] .

NATURE Monobasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_{15}H_{14}O_7$; 282 (found); 306 (calc.). [1]

CRYSTAL FORM AND COLOR Colorless needles[2] [1] .

MELTING POINT (°C) 201-202 (d.) [1] .

SOLUBILITY s. cold sodium bicarbonate; sl. s. water, organic solvents.[1]

STABILITY Very unstable, especially at pH 6 and above [1] .

OTHER REACTIONS Dissolves in cold $NaHCO_3$ with effervescence, giving a red color, later orange; purple color with $FeCl_3$ added to ethanol solution; negative Fehling.[1]

BIOLOGICAL ACTIVITY In vitro. Low antibacterial activity; inhibits Bacillus subtilis and Micrococcus pyogenes var. aureus at 100 μg/ml. Inhibits fungi at 12.5-25 μg/ml: Botrytis allii, Penicillium brevi-compactum, P. stoloniferum, Stachybotrys atra, Fusarium caeruleum, F. graminearum, Thamnidium elegans. At 50-100 μg/ml: P. digitatum, P. expansum and Stemphylium sp.[1]

60. CARBOMYCIN

The trademark of Chas. Pfizer & Co., Inc., for carbomycin is Magnamycin.

SOURCE Streptomyces halstedii [1] .

NATURE Monobasic [1-4] .

MOLECULAR FORMULA AND WEIGHT $C_{40-42}H_{67-71}NO_{16}$ [2] ; $C_{41-42}H_{67-69}NO_{16}$ [3, 4] ; 830, 840, 860, 864 (neut. equiv.).[2, 4]

/1/ c, 1 chloroform. /2/ From ethanol.

CRYSTAL FORM AND COLOR Slender, white, blunt-ended, needle-shaped crystals [1] ; colorless laths[1] [3] ; rectangular plates[2] [4] .

MELTING POINT (°C) 210-218 (d.) [2-4] .

OPTICAL ACTIVITY $[\alpha]^{25}_{D}$ = -58.6°[3] [1] , -56.1°[3] [4] , -54° ± 2[4] [2] , -56 ± 2[5], -55.2°[3] [2] .

UV ABSORPTION MAXIMA 238, 327 mμ[6] [3, 4] .

SOLUBILITY s. water (acid salts), most organic solvents; i. water (base), hexane.[1, 3]

STABILITY Most stable at pH 5-7[7]; stable for several months in dark at room temperature; unstable below pH 3 and above pH 9.[2-4]

OTHER REACTIONS Negative ninhydrin, Van Slyke, $FeCl_3$; positive Fehling, Tollens, 2, 4-dinitrophenylhydrazine, Baeyer permanganate, ceric nitrate; decolorizes Br; unaltered by serum; violet color at room temperature with 40% H_2SO_4 or 4 N HCl; intense yellow color with methanolic KOH solution; water-insoluble precipitate with trichloroacetic acid.[2-4] Acid hydrolysis yields 2 sugars: mycarose ($C_7H_{14}O_4$) and mycaminose ($C_8H_{17}NO_4$) from both carbomycin and carbomycin B [32, 33] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [4] . Colorimetric [5] .

BIOLOGICAL ACTIVITY In vitro. Active mainly against Gram-positive and a few Gram-negative bacteria, large viruses, rickettsiae, and certain protozoa. Fungi are insensitive. Inhibits (μg/ml) B. subtilis, B. anthracis, and B. mycoides, 0.2-1.5; Diplococcus pneumoniae, 0.01-0.15; Gaffkya tetragena, 0.3; Micrococcus pyogenes var. aureus, 0.2->25; Streptococcus pyogenes, 0.01-2.5; Str. faecalis, 0.2-12.5; Str. lactis, 0.16; Str. mitis, 0.04-1.25; Streptococcus spp, 0.1-12.0; Corynebacterium diphtheriae and C. bovis, 0.04-0.8; Clostridium tetani and Cl. botulinum, 0.4-1.5; Cl. perfringens, 6.2; Clostridium spp, 1.5-3.0; Erysipelothrix rhusiopathiae, 0.25; Listeria monocytogenes, H. pertussis, 3.1; Neisseria gonorrhoeae, 0.1-3.1; Mycobacterium spp, 0.4->25; N. catarrhalis, 0.02-0.8; N. meningitidis, 0.2-2.5; Hemophilus influenzae, 0.02-6.2; Pasteurella multocida, 6.25; Brucella bronchiseptica, 6.25-12.5; Escherichia coli, 3.2->100; pleuropneumonia-like organisms, <1.0. Generally resistant, 50 μg or more: Aerobacter aerogenes, Klebsiella pneumoniae, Proteus, spp, Pseudomonas spp, Salmonella spp, Shigella spp, and Candida albicans.[6, 7] Protozoa (μg/ml): Trypanosoma cruzi and Leishmania donovani sensitive to 32-62; T. rhodesiensis, 125; Trichomonas vaginalis, T. foetus, 250; Entamoeba histolytica, 32-125. Spermatozoa in man immobilized by 1000 μg/ml in 95 minutes.[8] Concentrations of 2 mg/ml had no effect on the virus of herpes simplex [34] .

In vivo. Good protection afforded against M. pyogenes var. aureus, Str. pyogenes, and D. pneumoniae infections in mice, with total doses of 5-50 mg/kg administered i.p. or s.c. [9] . Doses of 10 mg/kg, i.p., gave good protection against Past. multocida in mice; 65 mg/kg highly active in fowl typhoid infection (Salmonella gallinarum) in chicks; no protection against mouse infections with B. anthracis and Myco. tuberculosis.[30] High activity (in chick embryos, mice, guinea pigs, or cotton rats) against Rickettsia prowazeki, R. typhi, R. akari, R. tsutsugamushi, R. rickettsi, R. conori, North Queensland tick typhus, and Coxiella burneti; also against viruses of psittacosis, ornithosis, lymphogranuloma venereum, human pneumonitis, feline pneumonitis, and sporadic encephalomyelitis. [10, 25] Oral doses of 100 mg/kg ineffective in guinea pigs infected with Entamoeba histolytica [29] . Daily intramuscular doses of 20 mg/kg for 10 days cured experimental syphilitic orchitis in rabbits [35] . In rats, oral doses of 337-665 mg/kg/da effectively controlled experimental intestinal amebiasis [37] .

CLINICAL On basis of preliminary trials, carbomycin appears useful in therapy of infections, particularly those caused by Gram-positive organisms which are resistant to penicillin and other antibiotics. Favorable response has been reported in infections with Str. pyogenes treated with 1-2 g daily in divided oral doses.[11] Doses of 100-125 mg/kg for approximately 9 days were effective in children for control of infections caused by M. pyogenes var. aureus (pyoderma, deep abscesses, and pneumonia)[12] . Good response in pneumonia caused by D. pneumoniae and Str. pyogenes [22] ; in chronic urinary tract infections caused by enterococci [24] and in gonorrhea [26] . In a limited series of patients with primary or secondary syphilis, daily oral doses of 2-3 g promptly cleared lesions of Treponema pallidum [31, 36] . Preliminary trials suggest value in granuloma inguinale (donovanosis) [13] ; also indicate value in clinical amebiasis [38] and in tsutsugamushi disease [39] . Daily doses of approximately 1.5 g for 10 days gave good clinical response in amebic dysentery [14, 15] .

VETERINARY Daily oral doses of 25 mg/kg had a suppressive effect on experimental Neorickettsia helmintheca infection ("salmon poisoning") in dogs, but the infection was not completely eliminated [40] . In preliminary trials antibiotic appeared valuable in treating distemper complex in dogs [27] .

ACUTE TOXICITY LD_{50} in mice, 550 mg/kg, i.v.; 2950 mg/kg, s.c.; 1000 mg/kg, i.m.; >3500 mg/kg, per os. LD_{50} in rabbits, 700 mg/kg, i.v.; >5000 mg/kg, per os.[16]

/1/ From ethanol. /2/ From ethanol-water. /3/ c, 1 chloroform. /4/ c, 1 methanol. /5/ c, 7 chloroform. /6/ Absolute ethanol. /7/ 11 days at 25°C.

CHRONIC TOXICITY Five daily i.v. injections of 200 mg/kg, or same dose administered orally or i.m., for 20 weeks were well tolerated. No evidence of eighth cranial nerve damage in cats given daily i.m. doses of 200 mg/kg for 9 weeks.[16]

In man, daily oral doses of 2 g well tolerated [17, 23] ; nausea with occasional vomiting and diarrhea reported following daily oral doses of 2.5 g [18] .

ABSORPTION AND EXCRETION Wide variations in blood levels noted in animals and man after oral or parenteral administration; these levels are generally low. In rabbits, 100 mg/kg, i.v., gave serum levels of 10 μg/ml in 30 minutes which dropped to 2.2 μg/ml after 3 hours; following oral administration of 200 mg/kg, low levels of approximately 0.75 μg appeared in 2 hours and 0.1 μg at the fourth hour, with usually less than 1% of the total i.m. or oral dose recovered in the urine. However, wide distribution in tissues, exudates, or organ contents, equal to or exceeding the serum concentration, was noted. Little or no diffusion through blood-brain barrier.[19, 20] In man, following i.m. injection of 3.3-8.0 mg/kg, or oral doses of 12-18 mg/kg, peak serum concentrations of approximately 0.7 μg/ml declined to 0.1-0.3 μg in 3-4 hours [17, 19] .

RESISTANCE Certain test bacteria acquired resistance in vitro in a slow stepwise pattern similar to that exhibited by penicillin [1] . Cross resistance of streptococci and micrococci exhibited between carbomycin and erythromycin [21] .

ANIMAL NUTRITION Stimulated growth of chicks when incorporated in ration in concentration of 2 g per ton, and of baby pigs in concentration of 40 g/ton [28] .

61. CARBOMYCIN B
(Magnamycin B)

SOURCE Streptomyces halstedii [1] .

NATURE Weak base [1] .

MOLECULAR FORMULA $C_{41-42}H_{67-69}NO_{15}$ (proposed) [1] .

CRYSTAL FORM AND COLOR Colorless anisotropic plates, frequently hexagonal[1]. HCl: fine needles.[1]

MELTING POINT (°C) 141-144 (d.). HCl: 164-166 (d.).[1]

OPTICAL ACTIVITY $[\alpha]_D^{25} = -35^o$[2] [1] .

UV ABSORPTION MAXIMUM 278 mμ[3] [1] .

SOLUBILITY s. ethanol[4]; less s. water[5].[1]

STABILITY Stable 3 months at pH 5; relatively unstable at pH 3 and 10[6].[1]

OTHER REACTIONS May be isomeric with carbomycin; contains a single methoxyl group, a dimethylamino nitrogen group, and a volatile acid; yields methylmycarose isovalerate on hydration in methanolic HCl; vigorous acid hydrolysis yields $C_8H_{17}NO_4$; mono-acetyl, tetrahydro, and mono-acetyltetrahydro are biologically active derivatives. [1]

BIOLOGICAL ACTIVITY In vitro. Same antimicrobial spectrum as carbomycin [1] .

ACUTE TOXICITY LD_{50} in mice, by oral, i.p., and s.c. routes, comparable to that of carbomycin. Slightly higher toxicity by i.v. route. LD_{50}, 300 mg/kg.[1]

ABSORPTION AND EXCRETION In man, preliminary trials indicated that oral doses gave higher blood concentrations than those usually obtained with carbomycin. Following doses of 500 mg every 12 hours, serum levels of 0.3-0.6 μg/ml were maintained for 1-3 hours, with high concentrations in the urine and feces in 6-24 hours. No detectable levels in cerebrospinal fluid.[2]

62. CARDICIN

SOURCE Nocardia sp [1] .

NATURE Acidic [1] .

CRYSTAL COLOR White [1] .

/1/ From acetone. /2/ c, 2 chloroform. /3/ Absolute ethanol. /4/ 450 mg/ml at 25°. /5/ 0.1-0.2 mg/ml. /6/ Half-life, 10 days.

62. CARDICIN (Concluded)

SOLUBILITY Free acid: s. methanol. ethanol, aqueous butanol; i. water, saline, ether, acetone. Na salt: s. water, ethanol, aqueous butanol; i. ether, cold anhydrous butanol.[1]

STABILITY Fairly stable at wide temperature and pH range; stable at 5°C.[1]

QUANTITATIVE DETERMINATION Microbiological: Antiviral in eggs; Bacillus subtilis.[1]

BIOLOGICAL ACTIVITY *In vitro*. Inhibits (μg/ml) B. subtilis, Saccharomyces cerevisiae, <1; Mycobacterium sp, 2.5; Aspergillus niger, 5. Inactive against Escherichia coli, Proteus vulgaris, Salmonella typhosa. Inhibits bacteriophages. In chick embryo, antibiotic is active against strains PR-8 and FM-1 influenza virus.[1]

ACUTE TOXICITY LD_{100} in mice, 8.25 mg/kg, i.p. and s.c.[1] .

63. CARNEOLUTESCIN

SOURCE Penicillium carneo-lutescens [1] .

NATURE Oil containing C, H, O [1] .

SOLUBILITY s. ether, benzene, ethanol; sl. s. water. [1]

STABILITY Stable at room temperature at acid pH; less stable at higher pH.[1]

OTHER REACTIONS Negative $FeCl_3$, Fehling; activity greatly reduced by serum.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits M. pyogenes var. aureus at 1:1, 600,000 dilution, Streptococcus pyogenes at 1:800,000, Salmonella enteritidis at 1:100,000, Bacillus anthracis at 1:6, 400,000.[1]

64. CARZINOCIDIN

SOURCE Streptomyces sp [1] , S. kitazawaensis [3] .

FORM AND COLOR Brownish black powder [1] .

UV ABSORPTION MAXIMA None specific [1] .

SOLUBILITY s. alkaline water; i. organic solvents. [1]

STABILITY Unstable to heat, particularly at alkaline pH; stable at 5°C for 10 days.[1]

OTHER REACTIONS Positive xanthoproteic, Pauly; negative Millon, biuret, Adamkiewicz, Liebermann, ninhydrin, Neubauer-Rhode, diphenylamine, cysteine-H_2SO_4, nitroprusside, Folin, anthrone; culture also produces antimycin A.[1]

BIOLOGICAL ACTIVITY *In vitro*. Slight activity against Candida albicans, Torula utilis, and Saccharomyces cerevisiae. Bacteria are not sensitive.[1]

In vivo. Crude preparations showed antitumor activity. Daily i.p. doses of 10-20 mg/kg inhibited Ehrlich ascites carcinoma in mice; also active against Yoshida rat sarcoma and subcutaneous solid tumor induced by Ehrlich carcinoma.[2]

TOXICITY LD_{50} in mice, 4.7 mg/kg, i.v.; 43.5 mg/kg, i.p.[1] LD_0 in mice, 20 mg/kg, s.c. These animals tolerated daily doses of 10 mg/kg, i.p., for 7 days, and 40 mg/kg for 2 days. There was no necrosis at site of inoculation following 20 mg/kg/da, s.c., for 10 days.[2]

In vitro. Concentrations of 1 mg/ml did not hemolyze erythrocytes [2] .

65. CARZINOPHILIN

SOURCE Streptomyces sahachiroi, n. sp [1] .

UV ABSORPTION MAXIMA 217, 290 mμ[1]; 285-290 mμ[2].[1]

SOLUBILITY s. water, alcohols, acetone, butyl acetate, chloroform, benzol; i. petroleum ether.[1]

STABILITY Most stable at pH 7; relatively stable at pH 6-9; unstable below pH 5; thermolabile; unstable in air at acid pH; stable in H_2 gas.[1]

/1/ Water. /2/ 30 minutes in 0.1 N HCl or NaOH.

65. CARZINOPHILIN (Concluded)

OTHER REACTIONS Positive xanthoproteic; negative Molisch, Sakaguchi, Fehling, Benedict, ninhydrin, Schiff, $FeCl_3$, Tollens; no hemolysis; antibacterial activity highest at pH 6-7; serum, KCN, $Na_2S_2O_3$, $CS(NH_2)_2$ inhibit activity; glucose, cysteine enhance activity.[1]

QUANTITATIVE DETERMINATION Microbiological: Sarcina lutea [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium smegmatis, Myco. avium, Myco. phlei, Micrococcus pyogenes var. aureus, Bacillus subtilis, B. anthracis, Diplococcus pneumoniae, Streptococcus pyogenes, Brucella abortus, Br. melitensis, 2.5-10; Vibrio comma, 25; Proteus vulgaris, 50; Pseudomonas aeruginosa, 100. Nocardia asteroides is sensitive to 10 μg/ml. Resistant, >100 μg/ml: Salmonella spp, Shigella spp, Candida, Trichophyton interdigitale and other fungi.[1]

In vivo. Antitumor activity in rats against Yoshida sarcoma, Ehrlich carcinoma and ascitic hepatoma following single i.p. doses of approximately 1 mg/kg [1] . Daily i.p. doses of 2500 units/kg in mice had marked inhibitory effect on the following ascites tumors: Sarcoma 180, Ehrlich carcinoma, Krebs 2 carcinoma; there was little or no effect on solid tumors.[3]

CLINICAL Trials in 36 cases of malignant tumor described in which slight clinical improvement was noted in certain instances. The antibiotic was administered mainly by the i.v. route.[2]

ACUTE TOXICITY Mice tolerated only 2-3 mg/kg doses by i.v., i.p. or s.c. routes [1] .

66. CARZINOPHILIN A

SOURCE Streptomyces sahachiroi, n. sp [1] .

MOLECULAR WEIGHT 900-1200[1]; 800-1200[2].[1]

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 217-222 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]_D^{28} = +57.8^{\circ}$[3] [1] .

UV ABSORPTION MAXIMA 2% $NaHCO_3$, 218, 250, 283 mμ; 0.1 N NaOH, 230, 283 mμ; 0.1 N HCl, 216, 250 mμ; methanol, 218, 250, 283 mμ; ethanol, 219, 251, 290 mμ; ether, 219, 252 mμ; acetone, 210, 330 mμ; chloroform, 270 mμ; dioxane, 250 mμ; benzene, 282 mμ; ethyl acetate, 255 mμ; carbon tetrachloride, 262 mμ; carbon disulfide, 242, 378 mμ; ethylene dichloride, 255 mμ.[1]

SOLUBILITY s. acetone, chloroform, ethyl acetate, butyl acetate, benzene, dioxane, dilute alkaline water; sl. s., or i., methanol, ethanol, ether, carbon tetrachloride, petroleum ether, water.[1]

STABILITY Stable in dry crystalline state; very unstable in aqueous state, especially at non-neutral pH; also rapidly destroyed by thiourea, thioglycollic acid, cysteine, thioglycerin, methionine, hydroquinone, anthraquinone, vitamin B_2, chlorophyllin, hydrogen peroxide, formalin; destroyed in aqueous solution by UV.[1]

OTHER REACTIONS Positive Baeyer, xanthoproteic, ninhydrin, Br absorption, 2, 4-dinitrophenylhydrazine, Neubauer-Rhode, Na 1, 2-naphthoquinone-4-sulfonate, sodium nitroprusside, diphenylamine, anthrone. Infrared (in $CHCl_3$): 2.78, 2.90, 3.03, 3.30-3.45, 5.80-5.85, 6.10-6.26, 6.45, 6.68, 6.85, 7.10, 7.20, 7.33, 7.50-7.60, 7.82, 7.95-8.20, 8.47, 8.58, 8.89, 9.13-9.30, 9.35, 9.60, 10.44, 10.80, 11.10, 11.30, 11.75, 12.40, 13.2, 13.5 μ.[1]

BIOLOGICAL ACTIVITY In vivo. Single i.p. doses of 1-3 μg/kg in rats inhibited Yoshida sarcoma [1] .

TOXICITY LD_{50} in mice, 0.15 mg/kg, i.v.; LD_0, approximately 0.025-0.050 mg/kg.[1]

67. CATENULIN

SOURCE Streptomyces sp [1] .

NATURE Resembles neomycin B [1] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = +33^{\circ}$[4] [1] .

UV ABSORPTION End absorption only [1] .

STABILITY Stable in aqueous solution at pH 1.5-10 [1] .

/1/ Rast. /2/ Electroconduction. /3/ In chloroform. /4/ c, 1 methanol.

67. CATENULIN (Concluded)

OTHER REACTIONS Acid hydrolysis yields active fragment identified as neamine. Analysis of benzene sulfonate salt: C, 50.24, 50.24; H, 5.29, 5.26; N, 10.01, 10.16; S, 8.00, 7.8.[1]

BIOLOGICAL ACTIVITY In vitro. Active against Mycobacterium tuberculosis (including streptomycin-resistant strains) [1] . Inhibited Myco. ranae at 2 µg/ml [3] .

ACUTE TOXICITY LD_{50} in mice, 125 mg/kg, i.v. Neurotoxicity in cats following repeated daily doses of 100 mg/kg.[1]

PHYTOTOXICITY Highly toxic to duckweed plant (Lemna minor) at 1 ppm in tissue culture [2] .

MISCELLANEOUS Growth of wheat roots in tap water (but not in distilled water) was stimulated by addition of 0.1 ppm of antibiotic [4] .

68. CELESTICETIN

SOURCE Streptomyces caelestis, n. sp, resembling S. glaucous [1] .

NATURE Basic [2] .

MOLECULAR FORMULA AND WEIGHT $C_{24}H_{36-40}O_9N_2S$ (suggested); 517 ± 20 (equiv. wt. found; 490-537[1].[2]

CRYSTAL FORM AND COLOR Oxalate: white needles. Free base: amorphous, hygroscopic white glass.[2]

MELTING POINT (°C) Oxalate: 147-152. Salicylate: 139.[2]

OPTICAL ACTIVITY Oxalate: $[\alpha]^{24}_{D}$ = +106.6°[2], +105.8°[3]. Salicylate: $[\alpha]^{24}_{D}$ = +90.2°[2], +99.0°[3]. Free base: $[\alpha]^{24}_{D}$ = +126.6°[4].[2]

UV ABSORPTION MAXIMA 248, 341 mµ[5]; 240, 310 mµ[6].[2]

SOLUBILITY s. acidic, strongly basic solutions, more polar organic solvents; i. water at pH 7-10, ether, light hydrocarbons.[2]

STABILITY Stable at room temperature in aqueous solution at pH 5-7; unstable above pH 9; more stable in acid than in base, but unstable in 1 N HCl at 100°C.[2]

OTHER REACTIONS Infrared (in $CHCl_3$): 1670, 1645, 1614, 1584, 1517, 1486, 1462, 1390, 1324, 1300, 1250, 1210, 1157, 1136, 1085, 1046, 985, 957, 924, 900, 859, 850 (recip. cm); pK'_a 7.7, 9.8; positive $FeCl_3$, Molisch, Ekkert; white precipitates with Br water, Millon, $HgCl_2$; not precipitated by $AgNO_3$, lead acetate; negative Benedict, ninhydrin, iodoform; negative nitroprusside becoming positive after several days in 6 N HCl; no reaction with Br in CCl_4.[2]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria. Inhibits (µg/ml) Streptococcus hemolyticus, 0.2-3.1; Str. agalactiae, 0.8-1.5; Str. dysgalactiae, 0.8; Str. viridans, 1.5-12.5; Str. faecalis, 2.5-6.2; Diplococcus pneumoniae, 0.2-3.9; Micrococcus pyogenes var. aureus, 0.2-12.5; Clostridium novyi, 0.4; Cl. sporogenes, Str. mitis, 6.2. Inactive, >100 µg/ml: Hemophilus influenzae, Neisseria meningitidis, Escherichia coli, Proteus vulgaris, Klebsiella pneumoniae, Salmonella spp, Shigella spp, and Mycobacterium tuberculosis. Phytopathogens (µg/ml): Bacterium stewartii, Phytomonas fascians, and Xanthomonas pruni sensitive to 0.5. Erwinia carotovora, Agrobacterium tumefaciens not inhibited by 50 µg/ml. Inhibits Nocardia asteroides at 500 µg/ml. Fungi are resistant, >1000 µg/ml: Blastomyces dermatitidis, Coccidioides immitis, Hormodendrum compactum, Histoplasma capsulatum, Microsporum audouini, Candida albicans, Saccharomyces cerevisiae. In vitro action bacteriostatic; bactericidal at higher concentrations. Sensitivity increased with increasing pH. Activity not affected by serum, cysteine, methionine, or penicillinase.[1] Resistance did not develop readily but followed a stepwise pattern. No cross resistance with other antibiotics with the exception of erythromycin.

In vivo. Good protection in mice infected with Str. pyogenes and M. pyogenes var. aureus; slight activity against D. pneumoniae. No activity in infections with Salmonella typhosa, S. paratyphi, K. pneumoniae and Myco. tuberculosis. Inactive against viruses of Newcastle disease and influenza in ovo.[1]

PHYTOTOXICITY Concentrations of 1000 ppm non-toxic to foliage of apple, pear, and cherry trees [1] .

/1/ Calculated from rotation in HCl. /2/ Water. /3/ 1 N HCl. /4/ Chloroform, c, 0.5 in all. /5/ In 0.01 N alcoholic KOH. /6/ In 0.01 N alcoholic H_2SO_4.

69. CEPHALOSPORIN C

SOURCE Cephalosporium sp [1].

NATURE Mono-aminodicarboxylic acid [1].

MOLECULAR FORMULA AND WEIGHT $C_{16}H_{20}O_8N_3SNa \cdot 2H_2O$[1]. Na salt: 480±15 (equiv. wt., titr.); 470±15 (mol. wt., X ray).[1, 3]

CRYSTAL FORM Na salt: monoclinic [1, 3].

OPTICAL ACTIVITY Na salt: $[\alpha]_D^{20} = +103^\circ$ [1, 3].

UV ABSORPTION MAXIMUM 260 mμ [1, 3].

STABILITY Stable in aqueous solution at pH 2.5, room temperature; rapidly inactivated at pH 12.[1, 3]

OTHER REACTIONS Infrared of Na salt: 2.94, 3.06, 5.61, 5.77, 6.05, 6.29, 6.57, 7.17, 7.36 μ; pK values 3.1, <2.6, 9.8; not inactivated by penicillinase per se; positive ninhydrin; isolated from crude preparations of cephalosporin N; acid hydrolysis yields 1 mole of CO_2 and D-α-aminoadipic acid; α-amino and α-carboxyl groups are free; carbon skeleton of penicillamine in molecule, but not liberated on acid hydrolysis; hydrogenolysis with Raney nickel, followed by hydrolysis, yields an amino acid-like valine.[1] Negative nitroprusside; equal activity against Salmonella typhosa and Micrococcus pyogenes var. aureus, but 1/10 as active as cephalosporin N; heavy black precipitate with sodium plumbite in 50% NaOH at room temperature.[3, 4]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Neisseria meningitidis, N. gonorrhoeae, Hemophilus pertussis, 1.6; Micrococcus pyogenes var. aureus (including strains resistant to penicillin G), 12.5-400; Streptococcus pyogenes, Bacillus anthracis, Salmonella typhosa, S. schottmuelleri, 25; S. typhimurium, Klebsiella pneumoniae, Vibrio comma, 50; Escherichia coli, 200. [2] Less active than cephalosporin N [1].

In vivo. Multiple s.c. doses of 25-50 mg/kg protected mice against infection with Str. pyogenes; oral doses of 100 mg/kg were without effect.[2]

PHARMACOLOGY Very low toxicity; mice tolerated i.v. doses as high as 5000 mg/kg. Absorbed into blood following s.c. injection; poorly absorbed from gastrointestinal tract [2].

70. CEPHALOSPORIN N

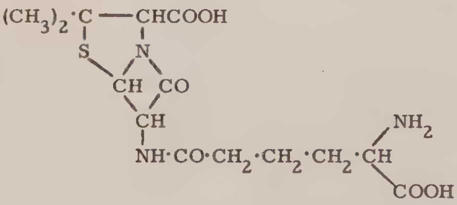
(Synnematin B) [7]

SOURCE Cephalosporium sp [1].

NATURE A hydrophylic penicillin [1, 3].

MOLECULAR FORMULA $C_{14}H_{21}N_3O_6S$ [5].

STRUCTURE



[5]

CRYSTAL FORM AND COLOR Ba salt: white powder [4].

OPTICAL ACTIVITY Ba salt: $[\alpha]_D^{20} = +187^\circ$[2] [4].

SOLUBILITY i. most organic solvents [1, 3]. Ba salt: s. water; sl. s. methanol; i. ethanol. [4]

STABILITY Unstable at room temperature below pH 4 and above 9; unstable at pH 7 in presence of heavy metal ions.[1, 5]

OTHER REACTIONS Inactivated by penicillinase; acid hydrolysis and further decomposition eventually forms a penicillamine (β-thiovaline); yields D-α-aminoadipic acid on hydrolysis; forms a dinitrophenyl derivative with fluorodinitrobenzene; penicillin W is very similar in nature.[1-3]

/1/ Provisional formula for crystalline sodium salt hydrate. /2/ c, 0.6 water.

QUANTITATIVE DETERMINATION Chemical: CO_2; hydroxylamine; iodine. Penicillinase.[4]

BIOLOGICAL ACTIVITY In vitro. Inhibits Gram-positive and Gram-negative bacteria at 5-10 μg/ml: Streptococcus pyogenes, Salmonella typhosa, S. typhimurium, S. enteritidis, S. schottmuelleri, Klebsiella pneumoniae, Bacillus subtilis, Vibrio comma, Corynebacterium ovis, Listeria monocytogenes, Brucella abortus, Micrococcus pyogenes var. aureus, Sarcina lutea, Str. viridans, Diplococcus pneumoniae, Neisseria meningitidis, N. gonorrhoeae, Pasteurella multocida, Hemophilus pertussis, Clostridium perfringens, Cl. tetani, Cl. septicum. At >40 μg/ml: penicillin-resistant M. pyogenes var. aureus, Mycobacterium tuberculosis. Action is essentially bactericidal. Cross resistance between this antibiotic and penicillin demonstrated with M. pyogenes var. aureus.[6]

PHARMACOLOGY Mice tolerated i.v. doses of 2000 mg/kg. Toxicity for mice, i.v., or rabbits, intracisternally, was less than that of penicillin. General behavior is like that of penicillin, but cephalosporin N is more slowly absorbed from the intestine and excreted at a lower rate. Following i.v. doses in rabbits, serum levels were higher than those obtained with an equimolar dose of penicillin. Cephalosporin N is destroyed like penicillin in the stomach by gastric juice and in the intestine by penicillinase-producing bacteria.[6]

71. CEPHALOSPORIN P SERIES

SOURCE Cephalosporium sp [2].

NATURE Acidic substances [2].

MOLECULAR WEIGHT Cephalosporin P_1: 580 (equiv. wt.) [2]; 601 ± 16 (X ray) [4].

STRUCTURE Cephalosporin P_1: Has a polycyclic hydroaromatic structure [2].

CRYSTAL FORM AND COLOR Cephalosporin P_1: needles.
P_3: white, greasy amorphous solid.
P_4: light fawn-colored crystals.[2]

MELTING POINT (°C) Cephalosporin P_1: 147.
P_2: 151.
P_4: 220-230.[2]

OPTICAL ACTIVITY Cephalosporin P_1: $[\alpha]_D = +28^\circ$ [2].

UV ABSORPTION MAXIMUM 211 mμ [4].

SOLUBILITY Cephalosporin P_1: s. most organic solvents; sl. s. petroleum ether, water.
P_2: s. ethanol, acetone, butyl acetate; less s. diisopropyl ether, benzene.
P_3: s. most organic solvents; sl. s. water.
P_4: s. acetone; sl. s. water, ether.[2]

STABILITY All thermolabile.
Cephalosporin P_1: Unstable at alkaline pH.
P_3: Less stable than P_1 and P_2; inactivated in air.
P_4: Stable at room temperature.[1, 2]

OTHER REACTIONS Inactivated by an impurity associated with penicillinase; not inactivated by heavy metals or cysteine; some resemblance to helvolic acid; associated with cephalosporin N.

Cephalosporin P_1 analysis: C, 65.8; H, 9.0; C-CH_3, 12.1; acetyl, 16.8; active H, 0.6. Yellow color with tetranitromethane in chloroform; positive Liebermann-Burchard, Salkowski; negative $FeCl_3$, Tollens, Legal, Rosenheim, Tortelli-Jaffé.[2, 4]

P_2 analysis: C, 65.25; H, 8.5; C-CH_3, 9.4; OCH_3, 5.8; acetyl, 18.8; active H, 0.8.[2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. albus, or var. aureus [1, 2].

BIOLOGICAL ACTIVITY In vitro. Inhibits Corynebacterium xerose, Mycobacterium phlei, M. pyogenes var. aureus, Streptococcus sp, Bacillus anthracis, B. mesentericus, Sarcina sp, Str. lactis, Pasteurella sp, Salmonella spp. Inactive against Pseudomonas aeruginosa, Serratia marcescens, Escherichia coli.[1] Activity of P_1 almost twice that of helvolic acid against M. pyogenes var. aureus. M. pyogenes var. aureus developed cross resistance to cephalosporin P_1 and helvolic acid.[2]

In vivo. Cephalosporin P_1: Inactive against mouse infections with M. pyogenes var. aureus. Substantial blood concentrations noted in mice following s.c. administration.[3]

TOXICITY Cephalosporin P_1: Toxic at approximately 500 mg/kg, i.v., in mice [3].

72. CEPHALOTHECIN

SOURCE Cephalothecium sp [1] .

MELTING POINT (°C) 124-126 (d.) [1] .

SOLUBILITY s. alcohols, acetone-ether, chloroform; sl. s. water. [1]

STABILITY Thermostable [1] .

OTHER REACTIONS No halogen, S, N, P [1] .

BIOLOGICAL ACTIVITY Antifungal activity in vitro [1] .

PHYTOPATHOLOGY Rice plants treated with the antibiotic resisted infection with Piricularia oryzae, the agent of rice blast. The addition of cephalothecin inhibited growth of the fungus and the absorption of ammonium ions from the culture solution, suggesting a relation between these two phenomena.[2]

73. CEREVIOCCIDIN

SOURCE Streptomyces sp resembling S. cacaoi [1] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{39}N_5O_4$; 420 (Rast); 437 (calc.) [1] .

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 249-250 (d.) [1] .

UV ABSORPTION MAXIMA None [1] .

SOLUBILITY s. methanol; sl. s. water; i. ethanol, acetone, ethyl acetate, ether, chloroform, benzene [1] .

OTHER REACTIONS Sublimes at 217-218°, but sublimate is decomposition product; positive Janovsky; negative Tollens, biuret, Fehling, ninhydrin, Sakaguchi, maltol, glucosamine; another component also active only against yeasts is obtained in culture fluids in greater quantity, but only thus far purified as a syrup [1] .

QUANTITATIVE DETERMINATION Microbiological: yeasts [1] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits yeasts (μg/ml): Saccharomyces cerevisiae, Sac. fragilis, Sac. pastorianus, Sac. saké, Zygosaccharomyces major, Hansenula anomala, Torula utilis, 3; Schizosaccharomyces pomb, 25. Candida albicans, Aspergillus niger, and bacteria (Micrococcus pyogenes var. aureus, Escherichia coli, and Mycobacterium tuberculosis) not sensitive to 10 μg/ml.[1]

74. CHARTREUSIN

SOURCE Streptomyces chartreusis, n. sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{18}H_{18}O_8 \cdot 2H_2O$ (proposed); 357 (Rast); 362.32 (calc.).[1]

CRYSTAL FORM AND COLOR Greenish-yellow crystals. Na salt: golden-colored needles or plates.[1]

MELTING POINT (°C) 180 [1] .

SOLUBILITY s. organic solvents [1] .

STABILITY Stable at pH 2-10; unstable at pH 2 or 10 with prolonged heating.[1]

OTHER REACTIONS Na salt soluble in water (20 mg/ml) at pH 9.5, but acid precipitates below pH 9 or on exposure to CO_2; crystals fluoresce.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus phage[1] [1] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits (μg/ml) Corynebacterium fascians, 0.1; Hemophilus pertussis, 0.25; Xanthomonas campestris, 0.5; Streptococcus pyogenes, 1; Mycobacterium tuberculosis, 1.7-2.0; Myco. avium, 1-2.5; Bacillus brevis, Myco. phlei, Myco. ranae, Sarcina lutea, M. pyogenes var. albus, 2.5; C. diphtheroides, Erysipelothrix rhusiopathiae, Myco. smegmatis, Neisseria catarrhalis, 5; B. cereus, B. subtilis, Lactobacillus casei, M. pyogenes var. aureus, Str. viridans, 10; X. pruni, 25; Str. lactis, Klebsiella pneumoniae, 100; Aerobacter aerogenes, Agrobacterium tumefaciens, Erwinia carotovora, Brucella bronchiseptica, Escherichia coli, Proteus

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/1/ Fumagillin method.

74. CHARTREUSIN (Concluded)

vulgaris, Pseudomonas spp, Serratia marcescens, Shigella sonnei, Salmonella spp, >100. Nocardia asteroides inhibited by 10 μg/ml. Geotrichum sp, Hormodendrum compactum, Cryptococcus neoformans, Sporotrichum schenckii, and Candida albicans not sensitive to 1000 μg/ml. Active against bacteriophages of Escherichia coli, Bacillus cereus, M. pyogenes var. aureus.[1, 2]

ACUTE TOXICITY Mice tolerated 2500 mg/kg, s.c. LD_{50} in mice (Na salt), 250 mg/kg, i.v.[1]

75. CHARTREUSIN-LIKE ANTIBIOTIC

SOURCE Streptomyces sp [1].

NATURE Glucoside; weakly acidic.[1]

MOLECULAR FORMULA $C_{32}H_{34}O_{14}$ [1].

MELTING POINT (^{o}C) 186-187 [1].

UV ABSORPTION MAXIMA 236, 266, 334, 381, 401, 424 mμ [1].

SOLUBILITY Slowly s. in saturated $NaHCO_3$ solution; more s. in dilute acid than in water.[1]

STABILITY Rapidly inactivated at room temperature [1].

OTHER REACTIONS Yellow-green color with alcoholic $FeCl_3$ solution; on heating above the melting point, it undergoes decomposition and separates into aglycone needle-like crystals; not reduced by hydrogen in presence of Pt at room temperature and normal pressure; no reaction with ketones; sublimates at about 260^{o}C; negative test for flavonols; acid hydrolysate gives positive Molisch and reduces ammoniacal $AgNO_3$.[1]

BIOLOGICAL ACTIVITY *In vitro*. Inhibits Gram-positive bacteria, including mycobacteria [1].

76. CHETOMIN

(Chaetomin)

SOURCE Chaetomium cochlioides [1].

NATURE Probably neutral [2].

MOLECULAR FORMULA AND WEIGHT $C_{16}H_{17}O_4N_3S_2$ (proposed); 310 (ethylene bromide).[2]

FORM AND COLOR White, non-crystalline powder [2].

MELTING POINT (^{o}C) 215, 218-220 (d.) [1, 2].

OPTICAL ACTIVITY $[\alpha]^{22}_{D} = +360^{o}$[1] [2].

UV ABSORPTION MAXIMUM 287 mμ [2].

SOLUBILITY s. acetone, ethyl acetate, chloroform, benzene, dioxane, pyridine; less s. ether, methanol, ethanol; i. water, petroleum ether.[1]

STABILITY Thermostable; stable to dilute acid but not alkalies.[1]

OTHER REACTIONS Not precipitated by picric acid, $HgCl_2$; no amino N; positive indole, Hopkins-Cole; negative biuret, Millon; inactivated by oxidizing agents, alkalies, hot acids; forms lead sulfide with sodium plumbite.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis, Micrococcus pyogenes var. aureus [1].

BIOLOGICAL ACTIVITY *In vitro*. Active against Gram-positive bacteria. Inhibits Micrococcus spp, Sarcina lutea, Bacillus spp, including B. subtilis in dilution of 1:30,000-1:200,000. M. pyogenes var. aureus very sensitive, inhibited by 0.002 μg/ml. Mycobacterium tuberculosis sensitive to 1:3000; Myco. phlei, 1:20,000; Phytomonas michiganensis, P. pruni, and P. phaseoli, 1:200,000.[1, 3] No activity against fungi and Gram-negative bacteria [4].

In vivo. Inactive [3].

TOXICITY Low toxicity in animals [2].

/1/ c, 1 chloroform.

77. CHLAMYDOSPORIN

SOURCE Fusarium sp [1] .

BIOLOGICAL ACTIVITY In vitro. Active against phytopathogens (μg/ml): Agrobacterium tumefaciens at 50; Xanthomonas malvacearum, 0.8. Active against human and animal pathogens (μg/ml): Bacillus anthracis, B. mesentericus, 0.2; B. mycoides, 0.4; Brucella abortus, 5.0; Br. suis, 0.9; Micrococcus pyogenes var. aureus, 0.3; Corynebacterium diphtheriae, Sarcina lutea, Mycobacterium tuberculosis, 7.5-10; Neisseria meningitidis, Streptococcus lactis, 4; N. gonorrhoeae, 10; N. catarrhalis, Clostridium septicum, Cl. perfringens, Cl. sporogenes, Str. hemolyticus, 2.[1]

78. CHLORAMPHENICOL

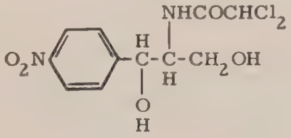
The trademark of Parke, Davis & Company for chloramphenicol is Chloromycetin.

SOURCE Streptomyces venezuelae [1] ; by synthesis [99, 100] .

NATURE Neutral [1, 4, 5, 8] .

MOLECULAR FORMULA AND WEIGHT $C_{11}H_{12}O_5N_2Cl_2$ [3, 4] ; 310 (Rast); 323 (calc.).[4]

STRUCTURE



[4, 5]

CRYSTAL FORM AND COLOR Colorless, elongated plates or fine needles [1, 2, 8] .

MELTING POINT (°C) 149.7-150.7 (corr.) [1-4, 8] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -25.5^{\circ}$ /1/ [1, 4, 8] , $+19^{\circ}$ /2/ [4] .

UV ABSORPTION MAXIMUM 278 mμ [2, 4, 8] .

SOLUBILITY s. propylene glycol, methanol, ethanol, butanol, ethyl acetate, acetone, diethyl ether; sl. s. chloroform, water, alkali; i. acid, benzene, petroleum ether, vegetable oils.[1, 2, 4, 5, 8]

STABILITY Thermostable; alkali labile.[1-3, 8]

OTHER REACTIONS Chlorine non-ionic; negative $FeCl_3$, Sakaguchi, Pauly, Molisch, biuret, Benedict; not hydrolyzed by papaine, trypsin, chymotrypsin, pepsin; hydrolyzed by some bacterial enzymes.[2, 3, 6, 8]

QUANTITATIVE DETERMINATION Microbiological: Shigella spp, Bacillus subtilis [2, 3, 7, 8] . Colorimetric [9] .

BIOLOGICAL ACTIVITY A broad spectrum antibiotic active against Gram-positive and Gram-negative bacteria, rickettsiae and larger viruses; no activity gainst fungi. In vitro. In general, most strains of the following bacteria are sensitive to 0.06-6.0 μg/ml: Aerobacter aerogenes, Alcaligenes faecalis, B. subtilis, B. mycoides, B. anthracis, Brucella abortus, Br. bronchiseptica, Br. suis, Br. melitensis, Corynebacterium diphtheriae, C. pyogenes, Diplococcus pneumoniae, Escherichia coli, Gaffkya tetragena, Hemophilus influenzae, H. pertussis, Klebsiella pneumoniae, Micrococcus pyogenes var. aureus, Mycobacterium leprae, Neisseria catarrhalis, N. meningitidis, N. gonorrhoeae, Pasteurella multocida, Salmonella typhosa, Salmonella spp, Sh. dysenteriae, Shigella spp, Streptococcus pyogenes, Stpretococcus spp, Vibrio comma. Most strains of the following are generally less sensitive or resistant, 10-25 μg/ml or more: Proteus vulgaris, Proteus spp, Clostridium spp, Pseudomonas aeruginosa, Malleomyces mallei, Myco. tuberculosis, Mycobacterium spp, pleuropneumonia-like organisms. Inhibition (μg/ml) of Actinomyces bovis, 5; Nocardia asteroides, 20. Spirochetes and protozoa: Borrelia recurrentis, 2.5-10; B. novyi, 10-50; Entamoeba histolytica, 125-1500; Trichomonas foetus, 2000.[10-18] Concentrations of 2 mg/ml had no effect on the virus of herpes simplex [69] . Inhibited H. aegyptius (a cause of conjunctivitis in man) at 0.2-1.6 μg/ml; also active against this agent in chick embryo [70] .

In vivo. S. c. treatment protected mice infected with K. pneumoniae and Sh. paradysenteriae; no protection against D. pneumoniae, Str. pyogenes and Str. viridans except slight activity with higher doses of >80 mg/kg.[19, 20] Relatively low doses showed high activity in mice infected with Past. pestis and Past. multocida; no activity displayed against infections with B. anthracis, Listeria monocytogenes and Erysipelothrix rhusiopathiae.[28, 31] High protection in chicks treated with 30 mg/kg/da i.p. doses against Salmonella gallinarum [31] , but relatively low activity in mice infected with S. typhosa [32] . Good protection against Borrelia novyi and V. comma following i.p. or drug-diet

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/1/ Ethyl acetate. /2/ Ethanol.

treatment [21, 22] . A transient suppressive action against Entamoeba histolytica noted in dogs, but larger doses of 700-1000 mg/kg/da in the diet were ineffective in cecal amebiasis in rats [23] . Prolonged survival time in mouse infections with Toxoplasma gondii when 1-2% was incorporated in the diet [24] . Little or no effect in experimental animals infected with Myco. tuberculosis, Leptospira icterohemorrhagiae, and a limited protection against Treponema pallidum in rabbits [10, 19, 25, 33] . Active against Plasmodium berghei in mice, P. gallinaceum and Borrelia anserina in chicks when relatively large doses were administered [26, 27] . In mice or in embryonated eggs, antibiotic was highly active against rickettsiae of epidemic, murine and scrub typhus, rickettsialpox, Rocky Mt. spotted fever, Q fever, and against the viruses of lymphogranuloma venereum and psittacosis. The following viruses were not affected: vaccinia, variola, St. Louis encephalitis, Japanese encephalitis, rabies, mumps, poliomyelitis, influenza A and B, lymphocytic choriomeningitis, eastern and western equine encephalitis, distemper, fowl laryngotracheitis, Newcastle disease and Theiler's intestinal virus.[10, 19, 29] Showed an adverse effect on experimental pinworm infestation; daily oral doses of 500 mg/kg in mice increased the worm burden approximately 2-fold [38] . Daily i.p. doses of 500 mg/kg had little or no inhibitory effect on several ascites and solid tumors in mice [78, 79] . An antitumor effect was observed when 3% chloramphenicol was added to sarcoma I or sarcoma 180 suspension immediately before inoculation (a dose of 4.5 mg of antibiotic per animal), or when a 30-mg pellet was implanted subcutaneously one day after inoculation of the tumor into mice via the same route; under these conditions the growth rate of tumors was reduced and survival time of animals was prolonged.[80] Daily doses of 0.4-1 mg/ml in drinking water effectively controlled experimental air-borne mouse pneumonitis virus infections in mice [71] .

CLINICAL This broad spectrum antibiotic has established clinical usefulness in a wide variety of infections caused by susceptible microorganisms, and is especially valuable against Gram-negative infections and the rickettsioses. Initial oral doses of 50-75 mg/kg, followed by 0.25 g every 2-3 hours, are usually recommended with larger doses (0.5 g) in severe infections.[30] Oral therapy with doses of 25-150 mg/kg/da, or parenteral administration in variable dosages, gave favorable results in typhoid fever, bacillary dysentery, cholera, gonorrhoea, chancroid, lymphogranuloma venereum, granuloma inguinale, urinary and intestinal tract infections caused by susceptible organisms, various surgical infections, bacterial pneumonia, epidemic and scrub typhus, Rocky Mt. spotted fever, Q fever, psittacosis, brucellosis, tularemia [34-37, 49] . Favorable results have also been reported in primary atypical pneumonia [39] , syphilis [40] , relapsing fever [41] , Carrion's disease (bartonellosis) [42] , nonspecific urethritis [43] , smallpox [44] , yaws and tropical ulcer [56] . Oral, plus i.v., medication has been beneficial in meningitis caused by N. meningitidis, H. influenzae and D. pneumoniae [45] . Total oral doses of 2.5-24.75 g over periods of 2-7 days were effective in the treatment of cases of anthrax infection in man [84] . Oral therapy with this or other broad spectrum antibiotics did not influence the course of herpes simplex, plantar warts, lichen planus, dermatitis herpetiformis, or discoid eczema [73] .

Topical use of 0.5-1% in ointment base was effective in the treatment of trachoma [72] . Topical therapy has given good clinical response in ocular infections caused by susceptible microorganisms [34] . In experimental chancroid induced in human volunteers by intradermal injection of cultures of H. ducreyi, the topical application of 1% chloramphenicol rapidly sterilized lesions which had developed and was also effective in prophylaxis of these lesions, in contrast to penicillin and chlortetracycline which were ineffective [82] . Valuable in prophylaxis and therapy of septic peritonitis and in prevention of infections which may develop in other parts of the body, e.g., complications of colon surgery [96] . Like other antibiotics, chloramphenicol was of no value in the treatment of Reiter's syndrome [98] . The antibiotic has been injected intrathecally with good results in cases of staphylococcal meningitis resistant to penicillin and streptomycin [97] . Despite a number of favorable reports, the direct value of this and other broad-spectrum antibiotics in pertussis, infectious mononucleosis, herpes zoster, and leptospirosis has been questioned [46] . Chloramphenicol is considered the antibiotic of choice in typhoid fever [30, 35, 47] .

VETERINARY Intramuscular therapy with 1 g/da for 2-3 days in calves was beneficial in control of shipping fever (hemorrhagic septicemia) [92] . Oral doses of 500 mg daily for 4 days prevented "scours complex" associated with Salmonella bredeny infection in calves [93] . Intramuscular doses of 25-35 mg/kg daily for 3 days successfully controlled virus pneumonia in pigs [94] . Useful in a wide variety of infections, e.g., diarrhea of calves, colts, and lambs, and conjunctivitis, keratitis, and gastroenteritis in dogs. Variable results in distemper complex [48] . Preliminary trial with 0.25-0.5% in feed suggests value in infectious sinusitis of turkeys [50] . 1-2 g/lb of feed gave excellent protection against artificially-induced fowl typhoid (S. gallinarum) in chickens [74] . 10% solutions in propylene glycol or methanol highly effective when topically used in foot rot in sheep [75] . Preliminary trials indicate oral medication of value in controlling contagious pleuropneumonia in goats [76] .

PHYTOPATHOLOGY Levels of 4-125 μg/ml inhibited development of crown gall disease in tomato plants induced with Agrobacterium tumefaciens [89] . Concentrations of 25-50 μg/ml increased resistance of wheat seedlings to infection with Xanthomonas translucens [90] .

TISSUE CULTURE Proliferation of fibroblasts and epithelial cells retarded by concentrations of 10 μg/ml; completely inhibited by 1000 μg/ml. [57] Growth of skin tissue inhibited by 550-830 μg/ml, spleen tissue by 1665-3330 μg/ml [58] .

ACUTE TOXICITY LD_{50} in mice, 245 mg/kg, i.v.; 1320 mg/kg, i.p.; 2640 mg/kg, oral. LD_{50} in rats, 171-278 mg/kg, i.v.; in rabbits, 117 mg/kg, i.v. LD_{50} in dogs, 150 mg/kg, i.v.; >101 mg/kg, i.m.; >300 mg/kg, oral. [5, 19]

78. CHLORAMPHENICOL (Concluded)

In vitro. Concentrations of 1.0-6.1 x 10^{-3} molar significantly inhibited respiration of human leuckocytes; similar concentrations of penicillin, streptomycin, and the tetracycline antibiotics, had little or no effect on oxygen uptake.[81]

CHRONIC TOXICITY Mice tolerated for 2 weeks 385 mg/kg/da in diet, 100 mg/kg, s.c., and 250 mg/kg, i.p. Dogs tolerated daily oral doses of >200 mg/kg for over 4 months, or daily i.v. doses of 25-50 mg/kg. No cumulative toxic effect observed on hemopoiesis, liver and kidney function or visceral tissues.[5]

In man, oral doses of 1-2 g/da for 10 days or more were well tolerated. Side reactions, e.g., nausea, headache, skin eruptions and enteritic symptoms, have been relatively rare and relatively minor.[51-53] In rare instances, certain disorders of the hemopoietic system, including aplastic anemia, have been ascribed to medication with this antibiotic, particularly after prolonged dosage [54, 55] . An occasional side effect, also occurring with other orally administered antibiotics, is stomatitis; secondary infections with yeast-like organisms have occurred, particularly in the peri-anal region and on the mucous surfaces of the vagina and lower rectum.[30] Continued topical use of dermatological preparations containing 1% of the antibiotic, is associated with a relatively low index of sensitization in contrast to penicillin, streptomcyin, and the sulfonamide drugs [83] .

ABSORPTION AND EXCRETION Readily absorbed following parenteral and oral administration and found in blood, urine, bile, and cerebrospinal fluid 2 hours after dosage in animals; disappeared within 4-6 hours after i.v., and 12-16 hours after oral, administration. S.c. doses of 100 mg/kg given twice daily produced blood concentrations of 11 µg/ml and 60 µg/ml urine levels in mice. Urinary excretion persisted for over a 24-hour period, with a recovery of 3.5-8.7% of the total dosage.[5, 19] In man, initial oral doses of 2.0 g, followed by 0.5 g 8 hours later, produced blood levels of 9-13 µg/ml in 2 hours, levelling off to 5 µg/ml at 8 hours, with subtherapeutic concentrations thereafter. About 10% of the oral dose of the antibiotic was recovered as such in the urine during the first 24 hours; the bulk of the antibiotic is excreted as inactive nitro compounds.[59, 60] Following oral administration, it diffuses into the spinal fluid and also through the placenta. Chloramphenicol is absorbed into the circulation following rectal administration in infants.[61]

RESISTANCE Resistant variants do not develop readily. Some Gran-negative bacteria developed 2 to 50-fold resistance after 7-12 subcultures in antibiotic-containing media. Thus far, no resistant strains of rickettsiae have been developed.[10, 29] Relatively few strains of bacteria show developed cross resistance between chloramphenicol and other antibiotics [62] .

MODE OF ACTION Bacteriostatic levels (1-5 µg/ml) inhibited protein synthesis in M. pyogenes var. aureus, but fermentation, respiration, free glutamic acid accumulation, and nucleic acid synthesis were depressed only by much higher concentrations of the antibiotic [85] . Growth inhibitory activity of 1 µg/ml concentrations against Escherichia coli was completely reversed by addition of 500 µg/ml of phenylalanine to culture medium, but this reversal did not occur with higher concentrations (2 µg/ml) of the antibiotic. Similar results were obtained with tryptophan and tyrosine.[86] Several species of bacteria which are sensitive to the antibiotic reduce the nitro group of chloramphenicol to the corresponding arylamine which is devoid of antimicrobial activity [87] . The antibiotic inhibits oxidation of succinate, fumarate, malate, and α-ketoglutarate by intact and crushed cells of Pseudomonas fluorescens, but not of oxalacetate, pyruvate, lactate, aspartate, and citrate [95] . Inhibits bacterial esterases of E. coli [65] . Has been suggested that a mode of action may be that of interference with bacterial synthesis of indole from anthranilic acid [66] . Addition of antibiotic to growing cultures of E. coli abruptly interrupts synthesis of proteins, but not that of nucleic acids [67] . When fed to rats, chloramphenicol decreases xanthine oxidase of liver, but has no effect on intestinal xanthine oxidase [68] .

ANIMAL NUTRITION Of slight or questionable value in the growth promotion of pigs [63] . Little or no effect on growth of chicks as compared with marked effect of other antibiotics [64] .

MISCELLANEOUS Following exposure to 2 mg/ml of antibiotic, the kappa particles were eliminated from the cytoplasm of "killer" strains of Paramecium aurelia [77] . Relatively high levels of chloramphenicol (300-500 mg per 14 lb of wheat) and certain other antibiotics were lethal to several varieties of coleopterous stored-grain insects within 30-60 days [88] . Like streptomycin and penicillic acid, the antibiotic inhibits carotenoid synthesis in the non-photosynthetic organism, Phycomyces blakesleeanus [91] .

79. CHLORORAPHIN

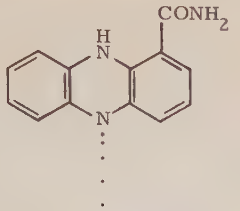
SOURCE Chromobacterium sp [1] .

NATURE Green pigment [2] .

MOLECULAR FORMULA $C_{28}H_{20}O_2N_6$ or $C_{13}H_{10}ON_3$ [1-3] .

79. CHLORORAPHIN (Concluded)

STRUCTURE



Probable [3].

CRYSTAL COLOR Green crystals [3].

MELTING POINT (°C) 225-230 (d.) [2].

SOLUBILITY sl. s. alcohol; i. chloroform, benzene, petroleum ether, aqueous acids and alkalies.[3]

BIOLOGICAL ACTIVITY In vitro. Inhibits hemolytic streptococcus at 100 μg/ml. Inactive against Micrococcus pyogenes var. aureus and Gram-negative bacteria (>100 μg/ml).[1]

80. CHLORTETRACYCLINE

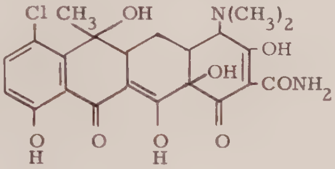
The trademark of Lederle Laboratories Division, American Cyanamid Company, for chlortetracycline is Aureomycin.

SOURCE Streptomyces aureofaciens, n. sp [9].

NATURE Amphoteric [1, 2].

MOLECULAR FORMULA $C_{22}H_{23}ClN_2O_8$ [4, 176].

STRUCTURE



[4, 176]

CRYSTAL FORM AND COLOR Base: acicular to bladed, small. HCl: rhomboid; clear vitreous lemon-yellow.[2]

MELTING POINT (°C) Base: 168-169 (uncorr.) [1]. HCl: d. above 210 [2].

OPTICAL ACTIVITY Base: $[\alpha]^{23}_{D} = -274.9^{\circ 1}$. HCl: $[\alpha]^{23}_{D} = -295.9^{\circ 1}$, $-227.9^{\circ 2}$.[1, 2]

UV ABSORPTION MAXIMA HCl: 365, 264, 226 $m\mu^3$; 370, 265, 251, 229 $m\mu^4$; 276, 248, 240, 223 $m\mu^5$.[2]

SOLUBILITY Base: s. dilute acids, alkali, "Cellosolve," "Carbitol," dioxane, pyridine; less s. methanol, ethanol, butanol, acetone, ethyl acetate, benzene; i. ether, petroleum ether. HCl: s. water, methanol; sl. s. ethanol.[1, 2]

STABILITY Thermolabile in strong acids, alkalies; stable at pH 2.5, unstable at pH 7.0 and above at 25°C.[3]

OTHER REACTIONS In alcoholic $FeCl_3$ greenish-brown color by reflected light, reddish color by transmitted light; precipitates with picric acid, Reinecke's acid, ammonium molybdate; UV shifts in acids, alkali; fluoresces in basic solution. Infrared bands of free base (recip. cm): 3420, 3050, 1643, 1609, 1580, 1523, 1302, 1231, 1209, 1121, 1080, 1050, 969, 943, 867, 844, 825, 805, 794, 788, 733, 713.[1, 2, 7, 8]

QUANTITATIVE DETERMINATION Microbiological: Especially Micrococcus pyogenes var. aureus [2, 3]. Fluorometric [8]. Colorimetric [5, 6, 8]. UV [7].

BIOLOGICAL ACTIVITY Active against Gram-positive and Gram-negative bacteria, rickettsiae and larger viruses, and certain protozoa. No activity against fungi. In vitro. Most strains of the following bacteria are sensitive to 0.002-7.5 μg/ml: Actinomyces bovis, Alcaligenes spp, Bacillus anthracis, B. cereus, B. subtilis, Brucella abortus, Br. bronchiseptica, Br. melitensis, Br. suis, Clostridium botulinum, Cl. feseri, Cl. histolyticum, Cl. novyi, Cl. perfringens, Cl. septicum, Cl. sordellii, Cl. tetani, Corynebacterium diphtheriae, C. renale, C. pyogenes, C. xerose, Diplococcus pneumoniae, Erysipelothrix rhusiopathiae, Hemophilus ducreyi, H. influenzae, H. pertussis, Klebsiella pneumoniae, Listeria monocytogenes, M. pyogenes var. aureus, Mycobacterium tuberculosis, Myco. leprae, Neisseria catarrhalis, N. gonorrhoeae, N. meningitidis, Nocardia asteroides, Paracolobactrum spp,

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/1/ Methanol. /2/ Water. /3/ 0.1 M phosphoric acid. /4/ 0.1 M KH_2PO_4 pH 4.3. /5/ 0.1 M K_2HPO_4 pH 8.9.

Pasteurella multocida, Past. hemolytica, Past. pestis, Past. tularense, pleuropneumonia-like organisms, Salmonella typhosa, S. paratyphi, S. enteritidis, S. schottmuelleri, Salmonella spp, Shigella dysenteriae, Shigella spp, Streptococcus pyogenes, Str. agalactiae, Str. dysgalactiae, Str. faecalis, Str. viridans, Vibrio comma, V. foetus. Inhibited Hemophilus aegyptius (causes a conjunctivitis in man) at 0.4-3.2 μg/ml; also active against the same agent in ovo [125] . Less sensitive (10-25 μg/ml), or resistant (>50 μg/ml): Aerobacter aerogenes, Escherichia coli, Myco. smegmatis, Proteus vulgaris, Proteus spp, Pseudomonas aeruginosa. Spirochetes and protozoa (μg/ml): Borrelia recurrentis, 1-25; Trichomonas foetus, 25-100; Trypanosoma cruzi, >1000; Entamoeba histolytica, 2->200.[10-28] Rous sarcoma virus inactivated by exposure to antibiotic, as evidenced by failure to develop tumors in chickens [27] .

In vivo. In general, there was good protection in mice with parenteral doses of 5-30 mg/kg, or with higher oral doses in infections with Str. pyogenes, Salmonella typhosa, Ery. rhusiopathiae, Past. multocida, D. pneumoniae, B. anthracis, Listeria monocytogenes, H. influenzae B, Proteus vulgaris, Escherichia coli, V. comma, K. pneumoniae, and several species of clostridia [29-36, 45] . No effect on Myco. tuberculosis in guinea pigs and mice [36, 67] . High activity against fowl cholera (Past. multocida) and fowl typhoid (S. gallinarum) in chicks [36, 38] . Survival time was prolonged in experimental tularemia in mice [39] . Active in low doses in experimental leptospirosis in hamsters and guinea pigs [40] , and in experimental plague (Past. pestis) in mice and monkeys [41] . Successful control of experimental toxoplasmosis in mice, but did not prevent carrier state [42] . Active against Bartonella muris infection in rats [43] , and was the most effective of several antibiotics tested against experimental toxoplasmosis in mice [44] . Three parenteral injections of 30 mg/kg effective against experimental rat-bite fever induced with Spirillum minus in mice and guinea pigs [130] . Good protection in mice against Borrelia duttoni and B. novyi [46] ; also against rabbit syphilis, but less active on a weight basis than penicillin [47] . In experimental relapsing fever in rats treated with heavy doses of the antibiotic, the organism (B. duttoni) was still present in the central nervous system 29 days later [131] . Suppressive effect on Brucella melitensis infection in mice [48] , and on Br. abortus in guinea pigs [49] . Good protection elicited against Plasmodium gallinaceum in chicks treated with high oral doses of 150-300 mg/kg/da [50] . Oral therapy with 100 mg/kg afforded high protection, but failed to be curative in infant rabbits infected intra-intestinally with V. comma [139] . Active in embryonated eggs against pleuropneumonia-like organisms isolated from chronic respiratory disease of poultry [134] . Daily i.p. doses of 50 mg/kg in mice and rats had no inhibitory effect on 21 varieties of transplantable solid tumors and 3 ascites tumors [132, 133] .

S.c. doses of 7-70 mg/kg/da gave 100% protection in mice infected with the viruses of psittacosis and lymphogranuloma venereum and with the rickettsiae of murine typhus, scrub typhus and rickettsialpox. Daily s.c. injections of 5-6 mg/kg gave high protection in guinea pigs against the rickettsiae of epidemic typhus, Q fever, and Rocky Mt. spotted fever. In embryonated eggs, single doses of 1 mg highly active against the same agents and also against the rickettsiae of boutonneuse fever, South African tick-bite fever and North Queensland tick typhus. The viruses of mouse pneumonitis, SF strain of human pneumonitis, feline pneumonitis and meningopneumonitis were also sensitive in ovo.[51, 59] Excellent protection in mice against feline pneumonitis [53] and gray lung virus infection [54] . Doses of 0.1-1.0 mg/ml in drinking water effectively controlled air-borne mouse pneumonitis virus infections in mice [126] . Completely inhibited development of pulmonary consolidation in cotton rats infected with Eaton's atypical pneumonia virus following daily i.p. doses of 14 mg/kg; the same strain of this virus was also inhibited in ovo.[55] Cleared lice of Rickettsia prowazeki [59] . No activity against the viruses of influenza B, canine distemper, rabies, Newcastle disease, Venezuelan equine encephalitis, poliomyelitis (MEF-1 strain), mumps, herpes simplex and foot and mouth disease [51, 56, 58] . Oral medication with 500 mg/kg/da suppressed pinworms (Aspiculuris tetraptera) in mice [60] . I.p. doses of 100 mg/kg had an adverse effect on Candida albicans, enhancing infections in mice [52, 64] .

CLINICAL This broad spectrum antibiotic has established value in a wide variety of Gram-positive and Gram-negative bacterial infections, rickettsioses and infections with the larger viruses. The minimum daily oral dose recommended for adults is 1 g divided into 250 mg doses; children should receive proportionately less, e.g., a 44-lb (approximately 20 kg) child may be given 50 mg 4 or 5 times daily. Total oral dosages of 4.5-20.5 g, over periods of 1-8 days, effectively controlled anthrax infection in man [135] . In seven cases of tick-borne relapsing fever in East Africa treated with 4 oral doses of 500 mg in 2 days, there was prompt clinical response, rapid disappearance of parasitemia, and no recorded relapse [136] . In children with cystic fibrosis of the pancreas, associated pulmonary infections were controlled by oral chlortetracycline, and there was a marked improvement in the nutritional status [165] . Oral therapy with this and other broad spectrum antibiotics did not influence the course of herpes simplex, plantar warts, lichen planus, pityriasis, dermatitis herpetiformis, or discoid eczema [127] .

For i.v. use, buffered antibiotic is usually administered in daily doses of 20-25 mg/kg divided into 2-4 injections administered at intervals of 12, 8, or 6 hours. These regimens, and oral therapy, have given good clinical responses in bacillary infections caused by E. coli, Aerobacter aerogenes, K. pneumoniae, Shigella spp, N. gonorrhoeae (including acute gonorrheal ophthalmia); also in chancroid, granuloma inguinale, brucellosis, tularemia, streptococcal and D. pneumoniae infections, and subacute bacterial endocarditis caused by Gram-positive and Gram-negative organisms. Clinical efficacy has been established in rickettsial infections and diseases induced by certain of the larger viruses: Rocky Mt. spotted fever, epidemic typhus, murine typhus, scrub typhus, Q. fever, Brill's disease, lymphogranuloma venereum and psittacosis. It is useful in acute extra-intestinal amebic infection, including amebic hepatitis and (with surgery) amebic abcess. It is also effective in urinary tract infections caused by susceptible Gram-positive and Gram-negative organisms, and in acute bronchitis, anthrax and otitis media. The antibiotic has found wide usage in the prophylaxis and treatment of surgical infections. Topical therapy is effective in ocular infections and dermatoses [10, 63, 78-81] .

In experimental chancroid in human volunteers, induced with intradermal injection of cultures of H. ducreyi, topical application of 3% calcium chlortetracycline ointment, or penicillin, 24 hours later had no effect in preventing development of infected lesions, in contrast to erythromycin and chloramphenicol which were effective [137]. In preliminary clinical trials the application of the antibiotic (3% in ointment base) to the axilla was effective in controlling the odor from apocrine sweat [128].

The value of this antibiotic in primary atypical pneumonia is established [82]. Chlortetracycline and oxytetracyline are the antibiotics of choice in psittacosis [83] and for topical use in trachoma [84]. Good clinical responses have been reported in non-specific urethritis [85], cervicofacial actinomycosis [86], and in infections with Balantidium coli [89]. Total oral doses of 70 g, over a period of 12 days, appeared as effective as penicillin in the secondary stage of syphilis [87]; excellent results have been noted in yaws and tropical ulcer [62, 88]. Local therapy is of value in vaginitis caused by Trichomonas vaginalis [90]. There is little or no evidence that chlortetracycline (and other antibiotics are of direct value in the therapy of measles, mumps, common cold, acute viral hepatitis, infectious mononucleosis, varicella, smallpox, viral encephalitides, lymphocytic choriomeningitis and influenza. Despite a number of favorable reports, the direct activity in pertussis, herpes zoster and leptospirosis is not well established.[78, 81, 91] The antibiotic is of little or no value in paratyphoid fever and certain other salmonelloses, or in infections caused by Proteus or Pseudomonas spp [78]. Chlortetracycline, like other antibiotics, was of no value in the treatment of Reiter's syndrome [164].

VETERINARY Of value in a wide variety of infections caused by susceptible organisms, including bovine infections (calf scours, pneumonia, foot rot, vibriosis, chronic bloat, heartwater, mastitis from micrococci or Str. agalactiae), equine infections (strangles, septicemia), and swine infections (dysentery, salmonellosis, baby pig diarrhea and pneumonia). In experimental anaplasmosis in splenectomized calves, the number of Anaplasma marginale in red cells was depressed following therapy [140]. Incorporation of 50-200 g per ton of feed resulted in increased weight gains and reduced mortality in swine affected with atrophic rhinitis, a disease of undetermined etiology [144]. In smaller animals successful treatment has been described in leptospirosis, coccidiosis, gastrointestinal infection, canine rickettsiosis, feline distemper, fowl typhoid, and topically in the therapy of skin, eye and ear infections [92-99]. Medication with 1 g per gallon drinking water controlled an epidemic of Erysipelothrix rhusiopathiae infection in mink [143]. A field outbreak of chronic respiratory disease in poultry was successfully reduced by therapeutic doses of 400 ppm in the diet for 14 days, followed by 100 ppm for 8 weeks [141]. According to another report, the use of 200 g per ton of feed failed to alter markedly the course of this disease (associated with pleuropneumonia-like organisms) in chickens [142]. Supplementation of diet with 36-100 g per ton of feed, or use of 250 ppm in drinking water, controlled outbreaks of blue comb disease in fowls ("pullet disease," avian monocytosis), a disease of undetermined cause [145, 163]. For systemic infections, the antibiotic is usually administered i.v. in daily doses of approximately 5 mg/lb of body weight (11 mg/kg), or as the initial dose with 2.5 mg/lb thereafter, or orally in initial doses of 25 mg/lb followed by 12.5 mg/lb every 12 hours. In mastitis, intramammary infusion of ointment has been used, containing 100-400 mg in 7 g ointment base, and for topical use in small animals 25 mg antibiotic per g of ointment base.[92, 94]

PHYTOPATHOLOGY Concentrations up to 115 μg/ml were non-toxic to tomato plants [157]. Highly effective in control of crown gall tumor of tomato and other plants in concentrations of 10-20 μg/ml[114, 115]. Effective in other bacterial diseases of plants, e.g., black rot of crucifers [124]. Accelerated photosynthesis and induced an abnormal increase in sucrose in the alga Scenedesmus [120].

ACUTE TOXICITY LD_{50} in mice, 134 mg/kg, i.v.; approximately 3500 mg/kg, s.c. LD_0, >200 mg/kg, i.p.; 1500 mg/kg, orally. LD_{50} in rats, 118 mg/kg, i.v.; LD_0, 200 mg/kg, i.p.; 3000 mg/kg, oral. Dogs, rabbits and guinea pigs tolerated i.v. and oral doses of 50 mg/kg.[31, 61]

In vitro. Proliferation of epithelial cells and fibroblasts retarded in tissue cultures containing 10 μg/ml; complete inhibition with 1000 μg/ml [67]. Using roller tube method, concentrations as high as 2500 μg/ml were required partially to inhibit human skin transplants in tissue cultures [146]. Outgrowths of skin tissue inhibited at 830-1250 μg/ml; spleen tissue not affected by highest test level of 5000 μg/ml [68]. High concentrations (1000 μg/ml) inhibited phagocytosis of M. pyogenes var. albus by polynuclear leukocytes [69]. In high concentrations antibiotic was non-toxic to human spermatozoa [70].

CHRONIC TOXICITY Dogs tolerated multiple i.v. doses of 20 mg/kg; daily oral doses of 100-200 mg/kg for 12 weeks were well tolerated by mice, rats, and dogs; repeated i.m. or s.c. doses of 20-50 mg/kg non-toxic to rabbits, rats, and dogs.[31, 61]

In man, daily oral doses of 15-30 mg/kg are usually well tolerated although nausea, vomiting, and diarrhea were noted in some patients, especially following doses of >500 mg [63]. An occasional side effect (also occurring with other orally administered antibiotics) is stomatitis; secondary infections with yeast-like organisms have occurred, particularly in the peri-anal region and on the mucous membrane of the vagina and lower rectum. Allergic reactions after topical use and other side effects have occasionally been reported [65, 66, 77]. Continued topical use of dermatological preparations containing 3% chlortetracycline is associated with a relatively low index of sensitization, in contrast to penicillin, streptomycin, and the sulfonamides [138]. Side reactions were few in a group of 300 children receiving continuous oral therapy of 10-20 mg/kg/da over prolonged periods of 1-5 years [165].

RESISTANCE Resistant variants of bacteria did not develop readily in vitro; resistance increased in some Gram-negative and Gram-positive organisms following 14-60 transfers in antibiotic-containing media.[29, 100] A considerable number of resistant strains of M. pyogenes var. aureus have emerged; in clinical experience this has not been a problem with other bacteria, e.g., streptococci, D. pneumoniae, N. meningitidis and N. gonorrhoeae. Organisms developing resistance to chlortetracycline generally show cross resistance with the other tetracycline antibiotics.[23, 101, 102] Occasional strains of Str. pyogenes have developed resistance to the tetracycline antibiotics in burned patients treated with oral chlortetracycline. These resistant forms were atypical in that they lost the capacity to propagate under aerobic conditions, except in media containing concentrated (4%) agar, and required anaerobiosis.[147]

ABSORPTION AND EXCRETION Readily absorbed following oral or parenteral administration, with good distribution in tissues and body fluids. In rabbits and dogs, an i.m. dose of 20-40 mg/kg produced serum levels of 0.3-1.25 μg/ml in 15-30 minutes. Three i.v. doses of 20 mg/kg at 2-hour intervals in dogs produced serum concentrations of 40 μg/ml and cerebrospinal fluid levels of 0.8 μg/ml within 2 hours, with rapid excretion in the urine during the first 2 hours.[61] In mice, a single i.m. dose of 150 mg/kg produced prolonged blood levels of 1 μg in 1-4 hours, leveling to 0.2 μg for as long as 72 hours; oral doses of 250 mg/kg gave a peak of 2.5-3.0 μg in 1-4 hours, with no detectable blood concentrations at 24 hours.[71] Serum levels in rats after oral administration were markedly increased (as high as 10-fold) by simultaneous administration of citric acid, malic acid, tartaric acid [72] , but this increase was not observed in man [73] .

In man, following a single oral dose of 500 mg, serum levels of 0.7-1.1 μg/ml appeared in 3-6 hours, declining to 0.2 μg in 12 hours, with detectable quantities (0.07 μg) in 24 hours. After doses of 0.5-1.0 g every 6-8 hours, serum concentrations of 2-6 μg/ml are noted with urine levels as high as 260 μg/ml. The antibiotic readily passes into the peritoneal fluid, cerebrospinal fluid, bile and milk and crosses the placental barrier. [63, 74, 75] Was detectable in significant amount (0.2-0.5 μg) in human brain tissue following oral or i.v. medication administered prior to prefrontal lobotomy [76] .

MODE OF ACTION Action primarily bacteriostatic; very high concentrations required for bactericidal activity.[29] Acts primarily on actively multiplying bacteria; electron microscopy reveals marked morphological changes in these cells, with little or no effect on fully grown organisms.[107] Concentrations of 150-200 μg blocked aerobic phosphorylation in mitochondria of tissue cells without interfering with respiration; in this respect the antibiotic resembled dinitrophenol and gramicidin.[103] In the absence of citrate, respiration of liver homogenates was suppressed; the antibiotic appears to block some part of the Krebs cycle.[104] Mn++ reverses antibiotic inhibition of the bacterial cell-free nitroreductase [105] . Concentrations of 100-300 μg/ml inhibit oxidation of glutamate and thus the respiration of murine and epidemic typhus rickettsiae in vitro [106] . Riboflavin reversed, in vitro, antibacterial activity of this antibiotic against E. coli [113] . Inhibition of oxidative phosphorylation in rat liver mitocondria occurred in the presence of magnesium, phosphate, and adenosinetriphosphate; addition of magnesium ion in higher concentrations caused reversal of this inhibition [148] . Bacteriostatic concentrations interfere with protein synthesis in bacteria [149] . Low levels inhibited synthesis of both pentose and desoxypentose nucleic acids in Lactobacillus casei; addition of folic acid and higher concentrations of vitamin B_{12} reversed this effect.[150] The hydroxylation of aniline to p-aminophenol by resting cells of mycobacteria was inhibited by small amounts of the antibiotic; this inhibition was partially reversed by a metabolite of p-aminobenzoic acid which appeared to function as a cofactor or cosubstrate in the hydroxylation reaction.[151] Very low concentrations of the antibiotic (1.0×10^{-6} molar) prevented the production of streptolysin S by resting cells of Str. pyogenes. Much higher concentrations of other antibiotics (penicillin, streptomycin, chloramphenicol) were required to inhibit development of this hemolysin. [152] Chlortetracycline (and penicillin) inhibited in vitro the deaminases of the intestinal microflora and prevented liberation of ammonia [153] .

ANIMAL NUTRITION Wide usage as a nutritional supplement for the growth stimulation of animals; generally low levels of approximately 9-20 g are incorporated in a ton of feed. Good growth responses in swine, young calves, lambs, poultry and experimental animals (rats, mice, rabbits and dogs, but not in guinea pigs which poorly tolerate this antibiotic).[108-112] An improvement in the growth curve is not observed in ruminants such as cattle; some observers have reported that incorporation of antibiotics at the usual levels in diets of these animals has a deleterious effect on the weight curve. This effect may be related to alterations in the rumen microflora.[108, 170, 171] Supplemental feeding of chlortetracycline enhanced growth of rats which had been made chronically diabetic with alloxan [154] . The response of rachitic rats to graded doses of vitamin D, as measured by the line test, was increased by adding the antibiotic to the rachitogenic diet [155] . When fed at levels ordinarily recommended for other species of animals, no growth improvement was observed in young rabbits fed a pelleted natural ration [156] . The experimental massive liver necrosis produced in rats fed on a necrogenic diet was prevented by addition of chlortetracycline to the diet. This inhibitory effect was attributed to elimination of intestinal bacteria which may utilize protective constituents of food.[172] The antibiotic had a highly protective effect in rats on experimental dietary hepatic cirrhosis and its sequelae, such as ascites and renal injury [173] . Anti-anemic effects have been described; dietary antibiotic had a beneficial effect on rats which had developed a macrocytic anemia following the surgical formation of an intestinal diverticulum [174] . It has been shown that these dietary antibiotics have a sparing effect on folic acid, B_{12}, and other B vitamins in animals on diets which were restricted with respect to these vitamins [166-169] .

The mechanism of growth stimulation by this and other antibiotics is poorly understood; may involve its therapeutic acitivity, increased bacterial synthesis of essential or stimulatory growth factors, inhibition of bacteria competing with host for essential nutrients, or inhibition of organisms which are deleterious because they produce toxic substances or are damaging to intestinal tissues. In this regard it is noteworthy that chlortetracycline and other antibiotics show no growth-stimulation effect in the developing chick embryo and in germ-free animals. Growth effects also reported in premature infants and young children.[108-112]

80. CHLORTETRACYCLINE (Concluded)

MISCELLANEOUS Concentrations of 16-32 μg/ml lethal to tadpoles; 4-10 μg/ml inhibited metamorphosis, but had no effect on the regenerative processes or longevity [158]. Supplemental feeding of high levels (equivalent to 20% of the weight of added food) caused a marked inhibition of somatic development and growth, but did not affect gonadal development in the tropical fish, Lebistes reticularis, more commonly known as the guppy [159]. Solutions containing 1 mg/ml were lethal to viviparous fishes within 10-30 minutes [160]. Relatively high levels of chlortetracycline (300-500 mg/14 lb of wheat) were lethal to several varieties of coleopterous stored-grain insects within 30-60 days [161]. The antibiotic displayed an ACTH-like activity by stimulating the adrenal cortex in rats; following a single i.v. injection of 50-100 mg/kg there was a decrease in adrenal cholesterol, a reduction in circulating eosinophils, increased weight of adrenals and liver, and a marked rise in the urinary levels of unconjugated gonadal hormones [162]. The neurological deterioration resulting from oral doses of methionine in humans with liver disease was prevented by oral doses of chlortetracycline [175].

Was the most effective antibiotic (of 12 tested) for preservation of fish. Concentrations of 0.5-2.0 μg/g incorporated in minced fish markedly inhibited bacterial spoilage; concentrations of approximately 2 ppm effective as meat preservative.[116, 117] Immersion in 3-40 ppm increased the shelf life of poultry stored under refrigeration [118, 119]. Yeasts for fermentation have been prepared by utilizing chlortetracycline and other broad spectrum antibiotics to inhibit growth of bacteria during the yeast propagation or storage period [121]. Effective in concentrations of 2-10 μg/ml for controlling bacterial contaminants characteristic of grain alcohol fermentation [122]. Silkworms fed on a diet containing this antibiotic and amino acids produced 8-14% more silk [123]. The antibiotic does not inhibit the curative action of thiamine on the polyneuritic pigeon; even larger doses had no effect on the in vivo action of thiamine or cocarboxylase [129].

81. CHROMIN

SOURCE Streptomyces sp resembling S. antibioticus [1].

CRYSTAL FORM AND COLOR Fine white needles [2].

UV ABSORPTION MAXIMA 281, 292.5, 305, 320 mμ [2].

SOLUBILITY Crude: s. methanol, aqueous butanol, chloroform, water (especially alkaline), acetone, acetonitrile, ethyl acetate. Crystals: i. most organic solvents, water.[1, 2]

STABILITY Thermo-, acid, and alkali labile [1, 2].

OTHER REACTIONS Tollens questionable; reduces Fehling; negative ninhydrin, Molisch, biuret, $FeCl_3$, Sakaguchi, Millon. Analysis: C, 58.19; H, 7.81; N, 2.29; no S, halogen. Infrared: 10.9, 9.9, 9.2, 8.8, 8.5, 7.7, 7.1, 6.4, 5.9 μ.[2]

QUANTITATIVE DETERMINATION Microbiological: Aspergillus niger [1].

BIOLOGICAL ACTIVITY In vitro. Active against certain yeasts and filamentous fungi. Candida albicans strains sensitive to 0.16-2.5 μg/ml. Inhibits, at 0.8-6.0 μg/ml, Absidia orchidis, Monascus spp, Helminthosporium oryzae, Botrytis cinerea, Glomerella cingulata, Penicillium italicum, P. chrysogenum, Ustilago zeae, Rhizopus nigricans, Aspergillus niger, Mucor spp, and Saccharomyces sake. Inhibits, at 6-12 μg/ml, Trichophyton interdigitale, T. purpureum. Bacteria are insensitive: Bacillus subtilis, Micrococcus pyogenes var. aureus, Escherichia coli, Mycobacterium avium, >1000 μg.[1] Some inactivation by serum [2].

ACUTE TOXICITY LD_{50} in mice, 36 mg/kg, i.p. [2].

82. CHRYSOMYCIN

SOURCE Streptomyces sp [1].

NATURE Neutral [1].

MOLECULAR FORMULA AND WEIGHT Chrysomycin: $C_{22}H_{20}O_7$ (proposed). Reduction product: $C_{22}H_{28}O_7$; 360 (found); 404 (calc.).[1]

CRYSTAL FORM AND COLOR Slender, greenish-yellow needles or rods [1].

MELTING POINT (°C) 255-260 (d.)[1] [1].

OPTICAL ACTIVITY $[\alpha]_D^{22} = +16^\circ$[2] [1].

UV ABSORPTION MAXIMA 247, 287, 390-400 mμ [1].

/1/ Micro-block, no sharp melting. /2/ c, 1 acetic acid.

82. CHRYSOMYCIN (Concluded)

SOLUBILITY s. concentrated HCl, pyridine, glacial acetic acid, dioxane; sl. s. methanol, higher alcohols, ethyl acetate; i. water, petroleum ether.[1]

STABILITY Solutions thermostable at pH 3-7 [1] .

OTHER REACTIONS Sublimes at 240°C without loss of activity; diffuses well in agar; dry crystals are photosensitive and turn brown on exposure to light; dissolves slowly on treatment with dilute alkali giving biologically inactive red solution that shows only end UV absorption; on hydrogenation with platinum oxide as a catalyst, 4 moles of H are taken up (colorless reduction product, MP 208°C, UV maxima 240, 355 mμ, biologically inactive).[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus cereus phage [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) B. subtilis, B. cereus, 0.1; Micrococcus pyogenes var. aureus, 0.2; Mycobacterium smegmatis, 0.6; Klebsiella pneumoniae, Pseudomonas aeruginosa, 25; Escherichia coli, 50. The following fungi inhibited by 50-100 μg/ml: Aspergillus niger, Chaetomium globosum, Gliomastix convoluta, Memnoniella echinata, Myrothecium verrucaria, Penicillium notatum, Phycomyces blakesleeanus, Stemphylium consortiale, Trichophyton mentagrophytes, Saccharomyces cerevisiae. Bacteriophages (μg/ml): B. cereus phage, 0.01; staphylophage, 0.04; B. subtilis phage, choleraphage, 0.4; E. coli phage T_2, 10.[1]

PHARMACOLOGY Doses of 250 mg/kg, i.p., were relatively toxic to mice but were sublethal; 100 mg/kg, i.p., well tolerated. Detectable blood levels after i.p. administration. Slowly eliminated in feces, with detectable amounts after 9 days. None detected in the urine.[1]

83. CINNAMYCIN

SOURCE Streptomyces cinnamoneus [3] .

NATURE Polypeptide [1] .

OPTICAL ACTIVITY Levorotatory [1, 3] .

UV ABSORPTION MAXIMUM End absorption: 230 mμ[1] [1, 2] .

SOLUBILITY s. water, 50% aqueous ethanol, 80% methanol, water-saturated n-butanol, glacial acetic acid; i. ether.[1, 3]

STABILITY Thermo- and acid stable[2]; unstable to alkali [1] .

OTHER REACTIONS HCl: positive Sakaguchi, biuret, azide-iodine; negative nitroprusside, ninhydrin, $FeCl_3$, Molisch, maltol, Tollens, reducing sugars; not inactivated by pepsin, trypsin, light. Amino acids tentatively identified: mesolanthionine, aspartic acid, arginine, glutamic acid, proline, phenylalanine, valine, β-methyllanthionine.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [2, 3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Gram-positive bacteria, including clostridia and mycobacteria. B. cereus, B. circulans, B. megatherium, B. subtilis, Mycobacterium phlei, Myco. smegmatis and Myco. tuberculosis are sensitive to 16 μg/ml or less. Inactive against streptococci, micrococci, Gram-negative bacteria and yeasts. [3]

ACUTE TOXICITY LD_{50} in mice: acetate, 5-10 mg/kg; HCl, 8-12 mg/kg, i.p. LD_0: HCl, 400 mg/kg, s.c. Marked hyperemia of ears and forefeet following i.p. administration of doses of 25 mg/kg or more.[4]

RESISTANCE Some strains of B. megatherium readily developed a high degree of resistance in vitro [5] .

84. CIRCULIN

SOURCE Bacillus circulans [1] .

NATURE Basic polypeptide [2, 3] .

MOLECULAR FORMULA AND WEIGHT $(C_{39}H_{74}O_9N_{12})_n$ [2, 3] ; 1200 (ionic sulfate) [3] .

FORM AND COLOR Sulfate: white, amorphous solid [2] .

MELTING POINT (°C) Sulfate: 226-228 [2, 3] . HCl: 232-236 (d.) [3] .

/1/ With shoulder at 250-260 mμ not in pure compound. /2/ 30 minutes at 94°C, pH 2.0-5.4.

84. CIRCULIN (Concluded)

OPTICAL ACTIVITY Sulfate: $[\alpha]_{D}^{25} = -61.6^{\circ}$[1] [2, 3] . HCl: $[\alpha]_{D}^{25} = -60.1^{\circ}$[2] [3] .

UV ABSORPTION MAXIMA None significant [3] .

SOLUBILITY s. water; less s. lower alcohols; i. hydrocarbons, chlorinated hydrocarbons, acetone, ether, glacial acetic acid.[1]

STABILITY Thermo- and acid stable; unstable above pH 7 in aqueous solution.[1-3]

OTHER REACTIONS Positive biuret, Van Slyke, formalin, 2, 4-dinitrofluorobenzene; negative ninhydrin, xanthoproteic; Knoop; inactivated by crude trypsin and in presence of lipase, but not pepsin; forms HCl, reineckate and helianthate salts; contains D-leucine, L-threonine, L-α-γ-diaminobutyric acid, and an optically active isomer of pelargonic acid.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Salmonella typhosa, Escherichia coli [1] . Release of cellular contents [12] .

BIOLOGICAL ACTIVITY In vitro. Primarily active against Gram-negative bacteria. Inhibits (μg/ml) Salmonella spp, 0.4-6.2; Brucella abortus, 0.3; Br. bronchiseptica, 0.8; Shigella dysenteriae, 0.4; E. coli, Klebsiella pneumoniae, Aerobacter aerogenes, Pseudomonas aeruginosa, Neisseria catarrhalis, 3.1; Serratia marcescens, Mycobacterium tuberculosis, 30; Proteus vulgaris, 67; Bacillus anthracis, B. subtilis, Micrococcus pyogenes var. aureus, Myco. avium, 100; Streptococcus faecalis, 10. [1] Inhibited Trichomonas vaginalis by direct tests at 200 μg/ml [10] . Phytopathogens: Xanthomonas phaseoli, X. campestris, X. beticola, Erwinia amylovora, E. carotovora sensitive to 0.4-3.1 μg/ml.[14]

In vivo. Doses of 10-16 mg/kg, administered s.c. or i.p., protected mice against infections with Salmonella typhosa, K. pneumoniae, Vibrio comma, and Hemophilus influenzae (type B). Ineffective as intestinal antiseptic in dogs.[4, 5, 7, 8]

TOXICITY LD_{50} in mice, 10 mg/kg, i.v.; 77 mg/kg, s.c. No evidence of chronic toxicity in mice and guinea pigs after repeated doses.[6] In dogs, toxicity shown by mucosal hyperemia; larger doses caused hemorrhages in the bowel.[4] Detectable blood levels in dogs, but not in rats, after oral administration [4, 6] . Low toxicity in tissue cultures: 3000-5000 μg required to inhibit growth of skin tissue, and >20, 000 μg for spleen tissue [9] .

PHYTOTOXICITY Highly toxic to onion root tips [11] .

MODE OF ACTION Bacterial cells exposed to circulin exhibit a leakage of cellular constituents and a loss of viability. Experimental evidence suggests that the lethal effects of the antibiotic are exerted in or near the bacterial cell walls. [13]

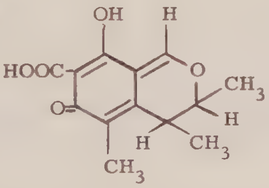
85. CITRININ

SOURCE Penicillium citrinum and other Penicillium spp, as well as Aspergillus spp [1, 9] .

NATURE Monobasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_{13}H_{14}O_5$ [1, 2] ; 259 (found); 250 (by analysis).[8]

STRUCTURE



[6, 7]

CRYSTAL FORM AND COLOR Golden prismatic needles or serrate plates from alcohol [5, 8] .

MELTING POINT (°C) 170, 175 (d.) [1, 2, 7, 8] .

OPTICAL ACTIVITY $[\alpha]_{5461}^{23} = -43.1^{\circ}$[3] [8] ; $[\alpha]_{D}^{18} = -37.4^{\circ}$[4] [7] .

SOLUBILITY s. hot ethanol, ethyl acetate, benzene, acetone, chloroform; sl. s. ether, petroleum ether, ethanol; i. water.[5]

STABILITY Thermostable; less stable at alkaline pH.[1]

/1/ c, 1.25 water. /2/ c, 2.094 water. /3/ c, 0.92 absolute ethanol. /4/ c, 1.15 ethanol.

85. CITRININ (Concluded)

OTHER REACTIONS Positive Tauber, $FeCl_3$; destroyed by cysteine; greenish-yellow fluorescence in UV; colorless in $NaHCO_3$ solution; orange-yellow in aqueous NaOH, later orange-red; bright lemon yellow in aqueous solution below pH 4.6, changing to orange-pink at pH 5.6-5.8 and to cherry red above 9.9.[2, 3, 8]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Escherichia coli [4] .

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria. Inhibits (in dilutions of 1:10,000-1:200,000) M. pyogenes, Streptococcus pyogenes, Bacillus subtilis, B. mycoides, Vibrio comma, Salmonella enteritidis, E. coli, Shigella dysenteriae. Salmonella typhimurium, S. paratyphi, Pseudomonas aeruginosa, Str. viridans, Mycobacterium phlei and Myco. smegmatis are less susceptible.[10, 13]

In vivo. No activity in mice infected with M. pyogenes var. aureus [12] .

ACUTE TOXICITY LD_{50} in mice, 35 mg/kg, s.c. or i.p. LD_{50} in rabbits, 19 mg/kg, i.v. Kidney damage followed repeated sublethal doses in rabbits. Depressed blood pressure in dogs. Dry citrinin very irritating to cornea and nasal mucosa of handlers.[11]

86. CITROMYCETIN

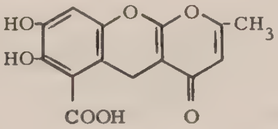
(Frequentic Acid)

SOURCE Strain of Penicillium frequentans [2] .

NATURE Dibasic acid [3] .

MOLECULAR FORMULA AND WEIGHT $C_{14}H_{10}O_7 \cdot 2H_2O$ [1, 3] ; 324 (found); 326 (calc.).[3]

STRUCTURE



[4]

CRYSTAL FORM AND COLOR Yellow crystals [2, 3] .

MELTING POINT (°C) 290-300 (d.) [3] .

OPTICAL ACTIVITY Inactive [2] .

SOLUBILITY s. ethanol, aqueous sodium carbonate; sl. s. chloroform, water; i. benzene, hexane.[2]

STABILITY Thermostable [2] .

OTHER REACTIONS Deep green color with $FeCl_3$; orange solution with green fluorescence with concentrated H_2SO_4; reduces ammoniacal $AgNO_3$; converts to citromycin when boiled with 2 N H_2SO_4; decomposes when boiled with 3 N NaOH.[1, 3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus at 1:8,000 dilution. Slight activity against Salmonella enteritidis (1:500 dilution). Activity reduced approximately 50% by serum.[2]

TOXICITY Na salt: Mice tolerated doses of 1200 mg/kg, i.v., and 2250 mg/kg, i.p. Evidence of kidney damage following multiple doses. Small amounts excreted in urine following large parenteral doses.[2]

87. CLITOCYBINS

SOURCE Clitocybe candida [1] .

CRYSTAL FORM AND COLOR Long, colorless, orthorhombic [2] .

MELTING POINT (°C) 77 [2] .

SOLUBILITY s. water, ethanol, acetone, chloroform, amyl acetate, sulfuric ether [1, 2] .

STABILITY Thermolabile [1] .

87. CLITOCYBINS (Concluded)

OTHER REACTIONS Readily diffusible; not a protein.[2]

BIOLOGICAL ACTIVITY In vitro. Inhibit Bacillus anthracis, Streptococcus pyogenes, Micrococcus pyogenes var. aureus, Erysipelothrix rhusiopathiae, Malleomyces mallei, Pasteurella multocida, Salmonella typhosa, S. paratyphi, Escherichia coli, Brucella abortus and Mycobacterium tuberculosis in dilution of 1:300,000-1:800,000 [3] .

In vivo. Slight protection against Myco. tuberculosis in guinea pigs. No activity in experimental infections with streptococci, or Past. multocida.[1] Claimed to have some effect in delaying the development of foot and mouth disease virus [5] .

TOXICITY Guinea pigs tolerated 20 mg doses. Higher s.c. doses induced necrosis at the site of injection and were lethal.[2, 4]

88. COELICOLORIN

SOURCE Streptomyces coelicolor [1] .

FORM AND COLOR Purplish-red powder [1] .

MELTING POINT (°C) 142-146 [1] .

SOLUBILITY s. water at pH 8 and above, acetone, ethyl acetate, chloroform, benzene, ethanol, methanol, ether; sl. s. water at pH 6-7; i. water at pH 5, petroleum ether.[1]

OTHER REACTIONS Red at pH 5, purple at pH 6-7, green at pH 8 and above [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus in dilution of 1:1,000,000; Bacillus subtilis, 1:400,000; Escherichia coli, Shigella dysenteriae, Salmonella typhosa, S. paratyphi, and S. schottmuelleri, 1:10,000.[1]

ACUTE TOXICITY LD_{50} in mice, 500 mg/kg, i.p. [1] .

89. COLICINES

SOURCE Escherichia coli and other members of Enterobacteriaceae [1] .

NATURE Polypeptides; proteic.

COLOR COLICINE K: colorless [4] .

SOLUBILITY s. water, acetic acid; sl. s. pyridine, aqueous phenol; i. other organic solvents.[1, 2, 4]

STABILITY Thermostable when acid or neutral; unstable to alkali[1].[1, 2, 4]

OTHER REACTIONS Dialyze through cellophane; destroyed by pepsin, trypsin, mouse kidney or liver tissue; precipitated from aqueous solution by neutral salts.[1, 2]

Colicine K: Free of nucleic acid; contains N, 6.5; P, 1.6; appears to have but 1 electrophoretic component in Tiselius apparatus; composed of carbohydrate, protein, lipid; destroyed by trypsin, chymotrypsin, contact with 1% formalin.[4]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Shigella dysenteriae, Sh. sonnei, Pseudomonas aeruginosa, Salmonella spp, Vibrio comma, Corynebacterium xerose, Mycobacterium phlei [1, 3] . Action is bactericidal; activity is enhanced by small amounts of serum.[1]

Purified colicine K: In concentrations of 1 μg/ml, inhibits E. coli [4] .

PHARMACOLOGY Lots vary in toxicity. LD_0 in mice, 900 mg/kg, i.v. Appear to be destroyed in the body; mice injected i.v. with 18.5 mg excreted less than 5% in urine.[1]

Purified colicine K: Toxic in mice and rabbits [4] .

MISCELLANEOUS Colicines resemble bacteriophages, but differ in that they are not transmitted by serial passage. Suggested that they may be precursors of phages [5] , although more recent evidence does not support this view [4] .

Purified colicine K is highly antigenic in rabbits, producing an antibody which precipitates the colicine, neutralizes its antimicrobial activity and agglutinates the strain of E. coli from which it is derived. Colicine K was shown to be chemically and immunologically unrelated to E. coli phage T6.[4]

/1/ Strain C_3: 13% loss at 100°C in 30 minutes, 22% in 1 hour.

90. COLIFORMIN

SOURCE A bacterium of Escherichia coli-Aerobacter aerogenes group [1] .

NATURE Polypeptide [1] .

MOLECULAR WEIGHT 4000 ± 400 (found) [1] .

UV ABSORPTION MAXIMUM 272 mμ[1] [1] .

STABILITY Thermostable at acid and neutral pH; unstable at alkaline pH.[1]

OTHER REACTIONS HCl analysis: C, 47.6; H, 8.22; Cl, 3.31; S, 0.23; P, 0.47; O, 33.15 (by difference); positive ninhydrin (after hydrolysis); Molisch; contains alanine, glycine, serine, glutamic acid, aspartic acid, lysine, valine, leucine.[1]

QUANTITATIVE DETERMINATION Microbiological: Pullularia pullulans [1] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits yeasts and fungi (μg/ml): Candida albicans 0.6-3.0; C. krusei, Cryptococcus neoformans, 0.6; Candida tropicalis, Hormodendrum pedrosoi, Microsporum gypseum, Trichophyton mentagrophytes, T. tonsurans, 3.[1] A wide variety of phytopathogenic fungi also sensitive [2] . Also active against fungi causing damage to wood, textiles, leather, and wood pulp [3] .

91. COLISTATIN

SOURCE An aerobic sporulating bacillus [1] .

SOLUBILITY Crude preparation: s. acid methanol and ethanol; i. butanol.[1]

STABILITY Thermostable [1] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits Escherichia coli, Proteus sp, Salmonella schottmuelleri, Shigella dysenteriae, Salmonella typhosa, M. pyogenes var. aureus, Diplococcus pneumoniae [1] .

In vivo. In mice, doses of 30,000 units/kg cleared Borrelia sogdianum from the blood within 24 hours [1] .

ACUTE TOXICITY Mice tolerated 100,000 units/kg by s.c., i.m., or i.v. routes [1] .

92. COLLINOMYCIN

SOURCE Mycelium of Streptomyces collinus [1] .

CRYSTAL FORM AND COLOR Orange prisms[2] [1] .

MELTING POINT (°C) 280-282 (uncorr.) [1] .

ABSORPTION MAXIMA 535, 575 mμ[3]; 480, 525 mμ[4].[1]

SOLUBILITY s. chloroform, acetone, dioxane; sl. s. ether, lower alcohols; i. water, petroleum ether, sodium bicarbonate.[1]

OTHER REACTIONS Sodium salt precipitates as violet precipitate at interface when yellow ether solution is shaken with 2 N Na_2CO_3, the aqueous phase being colored a weak violet; in pyridine-methanol and titanium trichloride, solution is first olive-green, then red; orange color (also fluoresces orange) in acetic anhydride, but becomes carmine red on addition of pyroboracetate, and after short heating has absorption maxima at 608, 555 and 515 mμ; yellow-red dioxane solution becomes pale yellow when sodium hyposulfite is added, but original color returns after standing in air.[1]

BIOLOGICAL ACTIVITY *In vitro*. Inhibits Micrococcus pyogenes var. aureus at 1:2,000,000 dilution [1] .

93. COMIRIN

SOURCE Bacterium antimyceticum, n. sp, resembling Pseudomonas fluorescens [1] ; Ps. antimycetica [2] .

NATURE Peptide containing an ether-soluble moiety [1, 2] .

FORM AND COLOR Whitish, amorphous powder [1] .

/1/ Broad band. /2/ From chloroform-methanol. /3/ 2 N NaOH. /4/ Concentrated H_2SO_4.

93. COMIRIN (Concluded)

MELTING POINT (°C) 230-235 (d.)[1] [2] .

SOLUBILITY s. organic bases and acids; less s. aqueous alcohols; sl. s. water; i. neutral organic solvents. [1, 2]

STABILITY Thermostable except in alkali[2] [1, 2] .

OTHER REACTIONS Precipitated by 50% $(NH_4)_2SO_4$ and protein precipitants; negative ninhydrin, glyoxylic acid, Molisch; positive Millon-Cole, Pauly, Sakaguchi, xanthoproteic, biuret. No free amino acid groups; dialyzes slowly through cellophane; acid hydrolysis yields mainly serine, glycine, aspartic acid; dinitrophenyl derivatives readily formed with 2, 4-dinitrofluorobenzene. Other amino acids present: leucine, isoleucine, tyrosine, arginine, lysine, α, γ-diaminobutyric acid.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Aspergillus flavus [1, 2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits the following yeasts and fungi in dilution of 1:25, 000 or more: Candida albicans, C. reukaufii, C. tropicalis, Torulopsis neoformans, Trichosporon sp, Zygosaccharomyces salsus, Debaryomyces matruchoti, Mycoderma valida, Saccharomyces cerevisiae, Saccharomyces spp, Schizosaccharomyces spp, Torulopsis utilis, Zygosaccharomyces spp, Epidermophyton sp, Hormodendrum sp, Sporotrichum schenckii, Trichophyton mentagrophytes, Trichosporium rubrum, Aspergillus spp, Cladosporium herbarum, Fusarium oxysporum, Mucor mucedo, Neurospora sitophila, Oidium lactis, Penicillium notatum, P. chrysogenum, Rhizoctonia solani, Rhizopus sp, Sclerotium rolfsii, Trichoderma viride, Verticillium spp, Botrytis allii, B. cinerea. No activity against bacteria.[1]

UTILIZATION Marked hemolytic properties preclude parenteral use. Topical use (1:10, 000-1:30, 000 in ointment base) suggested for mycotic infections of skin and ear. Usefulness as a fungicidal spray for plants also indicated. [1]

94. CONGOCIDIN

SOURCE Streptomyces ambofaciens, n. sp [1] .

NATURE Basic [1, 2] .

MOLECULAR FORMULA $C_{10}H_{21}O_3N_5\cdot HCl$ [1] ; $C_{17}H_{25}O_2N_9\cdot 2HCl$ [2] .

CRYSTAL FORM AND COLOR Almost colorless needles [1] .

MELTING POINT (°C) 205-210 (d.) [1, 2] .

OPTICAL ACTIVITY Inactive [1, 2] .

UV ABSORPTION MAXIMA 296, 235 mμ [2] .

STABILITY Stable in the crystalline state [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Gram-positive (including mycobacteria) and Gram-negative bacteria, with the exception of Pseudomonas aeruginosa and Brucella bronchiseptica [1] .

In vivo. Little or no activity in mice infected with Micrococcus pyogenes var. aureus, and Klebsiella pneumoniae. Slight activity in rats infected with Entamoeba histolytica following s.c. doses of 25 mg/kg/da. Single s.c. doses of 75-150 mg/kg suppressed infections with Trypanosoma congolense in mice; also T. brucei (including strains resistant to arsenicals).[1, 2]

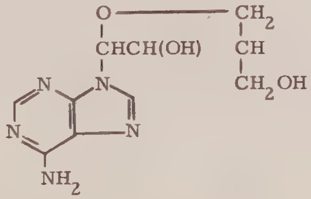
TOXICITY LD_{50} in mice, 75 mg/kg, i.v.; 200 mg/kg, s.c.; 5000 mg/kg, oral.[2]

95. CORDYCEPIN

SOURCE Cordyceps militaris (Link) [1] .

MOLECULAR FORMULA AND WEIGHT $C_{10}H_{13}O_3N_5$ [1] ; 247 ± 10 (found); 251 (calc.).[1]

STRUCTURE



[2]

/1/ Depends on rate of heating. /2/ Heating in acid results in apparent increase in activity, possibly because of strong surface-active and colloidal properties in aqueous solution.

95. CORDYCEPIN (Concluded)

CRYSTAL FORM AND COLOR Colorless needles or plates[1] [1] .

MELTING POINT (°C) 225-226 [1] .

OPTICAL ACTIVITY $[\alpha]_D^{20} = -47°$[2] [1] .

UV ABSORPTION MAXIMUM 260 mμ[3] [1] .

SOLUBILITY s. warm dilute mineral acids [2] .

OTHER REACTIONS Forms the picrate and picrolonate [1] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) B. subtilis at 10-100, Mycobacterium avium at 100. No activity against Micrococcus pyogenes var. aureus, Sarcina lutea, Escherichia coli, Clostridium perfringens, Proteus sp, and streptococci.[1]

In vivo. Daily i.p. doses of 100 mg/kg for 7 days in mice had no inhibitory effect on RC carcinoma [3] .

TOXICITY Of low order [2] .

96. CYCLOHEXIMIDE

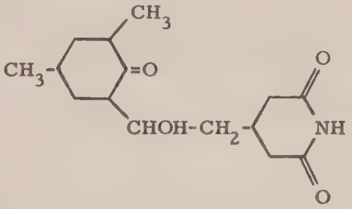
The trademark of The Upjohn Company for cycloheximide is Actidione.

SOURCE Certain strains of Streptomyces griseus [1] ; S. noursei [33] .

NATURE Weakly acidic [4] .

MOLECULAR FORMULA AND WEIGHT $C_{15}H_{23}NO_4$ [2-4] ; 254 (Rast); 281 (calc.).[2]

STRUCTURE



[3, 4]

CRYSTAL FORM AND COLOR Colorless plates [5] .

MELTING POINT (°C) 115-116.5 [2, 5] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -2.8°$[4] [5] , $-6.8°$[5] [2] .

SOLUBILITY s. water, all organic solvents except saturated hydrocarbons [1, 2] .

STABILITY Thermostable [1] .

OTHER REACTIONS Inactivated at room temperature by acetic anhydride, sodium acetate, dilute alkali [5] . Nonactin ($C_{30}H_{48}O_9$, a neutral, colorless crystalline compound, having very weak antibiotic properties) is found in cycloheximide-producing beers of Streptomyces viridochromogenes or S. olivochromogenes [37] .

QUANTITATIVE DETERMINATION Microbiological: Saccharomyces pastorianus [5, 6] .

BIOLOGICAL ACTIVITY In vitro. Little or no effect on bacteria. Antifungal activity; inhibits, at 0.2-50 μg/ml: Cryptococcus neoformans, Aspergillus niger, Sac. cerevisiae and other yeasts. In general, most fungal animal pathogens are not susceptible (>1000 μg/ml): Candida albicans, Epidermophyton floccosum, Blastomyces dermatitidis, Nocardia asteroides, Hormodendrum pedrosoi, Trichophyton spp.[1, 6, 12] Many phytopathogenic fungi are sensitive. Inhibited by 5 μg/ml or less: Sclerotinia fructicola, Diplocarpon rosae, Physalospora tucumanensis, Diaporthe citri, Endothia parasitica, Venturia inequalis, Ustilago tritici, U. zeae, Heterosporium iridis, Cladosporium fulvum, Diplodia zeae, Colletotrichum lagenarium, Sclerotium rolfsii.[8] Protozoa: Tetrahymena geleii and Euglena gracilis are sensitive to 1-5 μg/ml [9] . Sac. pastorianus developed a 68-fold increase in resistance in vitro (0.06-4.08 μg/ml) following 3 transfers in media containing the antibiotic [4] .

/1/ Transparent needles from ethanol and n-propanol, lustrous needles or plates from n-butanol, dull matted needles from water. /2/ Water. /3/ Ethanol. /4/ c, 9.6 methanol. /5/ c, 2 water.

96. CYCLOHEXIMIDE (Concluded)

In vivo. Daily i.p. doses of 1 mg suppressed production of ascites in mice injected with Ehrlich carcinoma, but failed to prolong survival time of the animals [24] . Was effective in control of experimental amebiasis (Entamoeba histolytica) in monkeys [10] . Intraperitoneal administration of 100 mg/kg/da had slight retarding effect on growth of a mouse tumor (Crocker sarcoma 180) [11] . Daily parenteral doses in mice had little or no inhibitory effect on sarcoma 180 [34] .

CLINICAL Good clinical response reported in a single patient with meningitis caused by Coccidioides immitis [12] , and in a case of Cryptococcus neoformans meningitis following i.m. and i.v. administration [13] . Another report describes intravenous therapy as unsuccessful in three cases of cryptococcosis [28] . The antibiotic was toxic when administered intrathecally [13] .

PHARMACOLOGY LD$_{50}$ in mice, 150 mg/kg, i.v.; in rats, 2.5 mg/kg, i.v., and 2.7 mg/kg, s.c.[7] Oral doses as low as 1 mg/kg were fatal to rats; rabbits tolerated approximately 4.5 mg/kg, per os.[14] Crude preparations were highly irritating to the skin [1] . Detectable blood levels in rats, guinea pigs and dogs following i.p. administration [7] .

MISCELLANEOUS In view of inactivity against bacteria and dermatophytes, antibiotic has been recommended for use in laboratory culture media in concentrations of approximately 100 μg/ml for the isolation of microorganisms from mixed cultures containing saprophytic fungi, e.g., aspergilli, penicillia [22, 23] . Incorporation of 40 μg/ml in agar media useful in laboratory isolation of actinomycetes in presence of contaminating fungi [29] . Liquid spray, containing 50-100 ppm antibiotic, provided good protection against brown rot fungus (Sclerotinia fructicola) on cling peach fruits [30] . Spraying with 25-50 ppm in casco summer oil prevented development of red cedar rust; no foliage injury observed as a result of this treatment.[31] In greenhouse and field tests, cycloheximide was the most effective of six antibiotics tested as spray in concentrations of 25-100 ppm for the control of stem rust of wheat [35] . Concentrations of 20-25 ppm sprayed on seedling plants effective in control of wheat stem rust [25] . The antibiotic did not increase the resistance of wheat seedlings to infection with Xanthomonas translucens [36] . Concentrations of approximately 10 ppm resulted in good control against powdery mildew of apple, onion, bean, and rose; also effective against cherry leaf spot, mint rust, and turf diseases.[15-19] 10-50 ppm inhibited Ascochyta pisi infection in peas, but was toxic to pea seeds [20] . Phytotoxicity of cycloheximide (e.g., to peach, tomato, bean, geranium) limits its use as agricultural fungicide on some crops [21] . Concentrations of 100 μg/ml induced specific aberrations in mitotic behavior in the cells of onion root [26] . At pH 6.0, cycloheximide markedly inhibited endogenous respiration of Tetrahymena pyriformis S, as well as its utilization of mono- and disaccharides, organic acids and amino acids [27] . Cycloheximide induced formation of gametangia in Allomyces arbuscula, thus transforming a sporophytic plant into a gametophytic plant [32] . Was effective as a rat repellent; paperboards when treated with 50 mg/sq inch reduced gnawing attacks [14] .

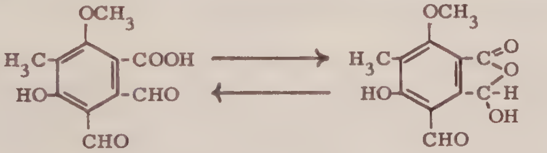
97. CYCLOPALDIC ACID

SOURCE Penicillium cyclopium (Westling).[1]

NATURE Dibasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_{11}H_{10}O_6$; 119 (equiv.).[1]

STRUCTURE



(Proposed) [1] .

CRYSTAL FORM AND COLOR Long fluffy colorless needles[1] [1] .

MELTING POINT (°C) 224-225 [1] .

SOLUBILITY Moderately s. ethanol, methanol, ethyl acetate; sl. s. ether, chloroform, hot benzene, boiling petroleum ether.[1]

OTHER REACTIONS Slowly soluble in cold aqueous NaHCO$_3$, yellow solution, effervescence; yellow solution in NaOH, deepens on warming; aqueous or ethanolic solution, ruby-red with FeCl$_3$; gelatinous orange precipitate with Brady; negative Fehling; Br water added to dilute aqueous solution gives transient buff color with no precipitate; trace exposed to NH$_3$ vapor turns brown, and if then dissolved in aqueous NH$_3$ gives purple color, fading after 2-3 hours to orange with yellow fluorescence; green fluorescence in methanolic solution in UV; transient pale yellow with bleaching powder; in pH 9.2 buffer and treated with aqueous suspension of 2, 6-dichloroquinone chloroimide,

---

/1/ From water.

forms a green color in 2 minutes, then blue-green in 10 minutes, reddish-brown after 3 days; sublimes readily in high vacuum at 170°.[1]

QUANTITATIVE DETERMINATION Microbiological: Inhibition of germination of Botrytis allii spores [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits germination of B. allii spores at 2.5 μg/ml. (Cyclopolic acid is inactive; no inhibition of B. allii at 320 μg/ml.) [2]

98. DECHLOROGRISEOFULVIN

SOURCE Penicillium janczewski and P. griseofulvum (Dieckx).

NATURE Neutral [1] .

MOLECULAR FORMULA AND WEIGHT $C_{17}H_{18}O_6$ [1] ; 306 (Rast)[2] .

STRUCTURE Dechloro-analogue of griseofulvin [1, 2] . (See also griseofulvin.)

CRYSTAL FORM Needles [2] .

MELTING POINT (°C) 179-181 [1, 2] .

OPTICAL ACTIVITY $[\alpha]_D^{19} = +390^{\circ 1}$ [1, 2] .

UV ABSORPTION MAXIMA 250, 286, 325 mμ [2] .

OTHER REACTIONS Dechlorogriseofulvin gives intense blue-violet color with HNO_3 at room temperature, griseofulvin giving a pale yellow color under same conditions (sensitive to 1 μg in a solid mixture).[1]

QUANTITATIVE DETERMINATION Microbiological: Botrytis allii response [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits B. allii at 6.25 μg/ml, in contrast to griseofulvin which inhibits this organism at 0.5 μg/ml.

99. DEXTROMYCIN

SOURCE Streptomyces sp resembling S. fradiae.

NATURE Base [1] .

MELTING POINT (°C) Helianthate: 227-228° [1] .

OPTICAL ACTIVITY HCl: $[\alpha]_D^{25} = +61.0^\circ$ [1] .

OTHER REACTIONS Resembles neomycin; recovered by same methods used with streptothricin and streptomycin; no maltol on alkaline hydrolysis; negative Sakaguchi; diffuses slowly through agar.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, Sarcina lutea, 0.1-0.2; Corynebacterium diphtheriae, 0.125; Klebsiella pneumoniae, 0.25; Micrococcus pyogenes var. aureus, 0.4-0.5; Mycobacterium avium, 0.5; Proteus vulgaris, Escherichia coli, 1.0-1.25; Vibrio comma, 2-8; Hemophilus pertussis, 4; Salmonella typhosa, 4-8; Shigella dysenteriae, 4-16; Myco. tuberculosis var. hominis, 5; Salmonella enteritidis, 8; Pseudomonas aeruginosa, 64; Streptococcus pyogenes, 125-250. Resistance did not develop readily in vitro. Fungi are not sensitive, >20,000 μg/ml: Aspergillus oryzae, A. niger, Penicillium spp.[1, 2]

In vivo. S. c. doses protected mice against S. typhosa; slight activity against H. pertussis infection. No activity in rats with transplanted Yoshida sarcoma.[2]

ACUTE TOXICITY LD_{50} in mice, 50 mg/kg, i.v.; 750-1000 mg/kg, s.c.; 1250 mg/kg, oral [1, 2] .

100. DIATRETYNES

SOURCE Clitocybe diatreta [1] .

NATURE Polyacetylene [1-3] .

MOLECULAR FORMULA AND WEIGHT Diatretyne 1: $C_8H_5NO_3$ [2] ; 159 (ebull.); 163 (calc.).[2]
Diatretyne 2: $C_8H_3NO_2$; 145.11 (calc.).[4]

/1/ c, 1 acetone.

100. DIATRETYNES (Concluded)

STRUCTURE Diatretyne 1: $HOOCCH{=}CHC{\equiv}CC{\equiv}CCONH_2$ [3] .
Diatretyne 2: $HOOC{-}CH{=}CH{-}C{\equiv}C{-}C{\equiv}C{-}C{\equiv}N$ [4] .

MELTING POINT (°C) 198 (uncorr.)[1] [2] .

UV ABSORPTION MAXIMA Diatretyne 1: 225, 260, 275, 291, 310 mμ[2] [1] .
Diatretyne 2: 230, 240, 270, 285, 303, 323 mμ[2] [1] .

STABILITY Diatretyne 1: Very unstable [1, 2] .

OTHER REACTIONS Diatretyne 1: pK 3.3; catalytic reduction product $C_8H_{15}NO_3$ is a colorless, crystalline solid, MP 144-145°C (uncorr.).[2, 3]

BIOLOGICAL ACTIVITY In vitro. Diatretyne 1: Inhibits Micrococcus pyogenes var. aureus at concentration of 0.1 μg/ml [4] .
Diatretyne 2: Apparently no antibacterial activity; no inhibition of Micrococcus pyogenes var. aureus at 1000 μg/ml. Antimicrobial activity, originally attributed to diatretyne 2, caused by contamination with diatretyne 1.[4]

101. DIPLOCOCCIN

SOURCE Streptococcus lactis.[2]

NATURE Protein-like [1] .

OPTICAL ACTIVITY Levorotatory [1] .

SOLUBILITY s. water; i. absolute ethanol.[1]

STABILITY Thermostable in acid; unstable in alkaline solution.[1]

OTHER REACTIONS Positive protein tests with the exception of Millon, Heller; negative Molisch; precipitated by half-saturated $(NH_4)_2SO_4$, tannic acid; slow diffusion through collodion; positive arginine, tyrosine, tryptophan.[1]

QUANTITATIVE DETERMINATION Microbiological: Streptococcus cremoris [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Str. cremoris, Str. hemolyticus, Str. lactis, and Micrococcus pyogenes var. aureus in dilution of 1:10,000-1:200,000 [1] .

102. DROSOPHILINS

SOURCE Drosophila substrata [1] .

NATURE Drosophilin A: p-methoxytetrachlorophenol.
C: polyacetylene.[2, 3]

MOLECULAR FORMULA AND WEIGHT Drosophilin A: $C_7H_4O_2Cl_4$ [2] ; 249 (found); 262 (calc.) [1] .

CRYSTAL FORM AND COLOR Drosophilin A: white crystals [1] .

MELTING POINT (°C) Drosophilin A: 118 (corr.) [1] .

OPTICAL ACTIVITY Drosophilin A: inactive [1] .

UV ABSORPTION MAXIMA Drosophilin A: 301 mμ.
C: 238, 251, 265, 280 mμ[3] [3] .
D: 217, 259, 274, 290, 309 mμ[4] [1] .

SOLUBILITY s. most organic solvents; sl. s. water. [1]

OTHER REACTIONS Drosophilin B is identical with pleuromutilin; C and D, but not A, precipitated from aqueous solution by $AgNO_3$. A: positive $FeCl_3$, negative 2, 4-dinitrophenylhydrazine, reduces alkaline permanganate and alkaline $AgNO_3$. UV of alkaline conversion product of C: 233, 243, 264, 273, 279, 290, 309, 330 mμ[5]; 230, 241, 264, 273, 279, 289, 308, 329[6]; of D: 233, 244, 257, 273, 290, 309, 330 mμ[5].[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

/1/ Explodes, no melting. /2/ 95% ethanol. /3/ Ether. /4/ Ethanol. /5/ Borate buffer, pH 10. /6/ Phosphate buffer, pH 2.

102. DROSOPHILINS (Concluded)

BIOLOGICAL ACTIVITY In vitro. Drosophilin A: Inhibits M. pyogenes var. aureus, 16; Bacillus subtilis, 31; B. mycoides and Mycobacterium smegmatis, 63; Escherichia coli, 125; Klebsiella pneumoniae, Pseudomonas aeruginosa, 250 μg.[1, 5] Fungi (μg/ml): Chaetomium globosum, Memnoniella echinata, Trichophyton mentagrophytes, 2; Gliomastix convoluta, Penicillium notatum, 8; Aspergillus niger, Myrothecium verrucaria, Stemphylium consortiale, 16; Saccharomyces cerevisiae, 31. High activity against phages of Micrococcus pyogenes and Vibrio comma.[5] In tissue cultures, partially inhibited Y-SK strain of poliomyelitis virus in concentration of 4-8 mg/ml. Concentrations >8 mg/ml are toxic.[4]

B: (See pleuromutilin.)

C: In vitro. Inhibition of M. pyogenes var. aureus, B. subtilis, E. coli, Ps. aeruginosa, Myco. smegmatis, and K. pneumoniae at 0.03-32.0 μg/ml [1] .

D: Active only against M. pyogenes var. aureus and B. subtilis at 2-4 μg/ml [1] .

TOXICITY Drosophilin A: Mice tolerated single i.v. doses of 50 mg/kg [5] .

MISCELLANEOUS Drosophilin A: Ineffective as spray in control of early blight of tomato plants; toxic to tomato plants at 200-400 ppm.[5] Some molluscacide activity; 10 ppm lethal for snail (Australorbis glabratus) in 24 hours. [5]

103. EHRLICHIN

SOURCE Streptomyces sp resembling S. lavendulae [1] .

STABILITY Thermostable; less stable in fermented broths; acid labile[1].[1]

OTHER REACTIONS Dialyzes without loss of activity; resists tryptic digestion.[1]

QUANTITATIVE DETERMINATION Microbiological: Influenza B virus [1] .

BIOLOGICAL ACTIVITY In vitro. Antiviral activity; no effect on bacteria, fungi and bacteriophages. Inhibits influenza A and B viruses.[1]

In vivo. Active against influenza B virus (suppressive effect on pulmonary consolidation in mice and in chick embryos). No activity against influenza A virus.[1]

ACUTE TOXICITY Mice tolerated 100 mg/kg, i.p.; 300 mg/kg, s.c. Necrosis developed at site of s.c. injection of 100 mg/kg doses.[1]

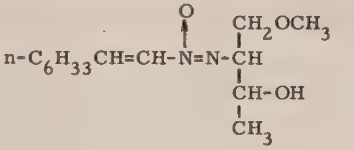
104. ELAIOMYCIN

SOURCE Streptomyces hepaticus [2, 3] ; S. gelaticus [4] .

NATURE A neutral oil [1-3] .

MOLECULAR FORMULA AND WEIGHT $C_{13}H_{26}N_2O_3$ (proposed); 244 (found); 258 (calc.).[2, 3]

STRUCTURE



$$n\text{-}C_6H_{33}CH{=}CH\text{-}\overset{\overset{O}{\uparrow}}{N}{=}N\text{-}\underset{\underset{\underset{CH_3}{|}}{\underset{CH\text{-}OH}{|}}}{\overset{\overset{CH_2OCH_3}{|}}{CH}}$$

[5]

COLOR Light yellow [2, 3] .

OPTICAL ACTIVITY $[\alpha]^{26}_{D} = +38.4^{\circ}$[2] [2, 3] .

UV ABSORPTION MAXIMUM 237.5 mμ [2, 3] .

SOLUBILITY s. organic solvents; sl. s. water [2, 3] .

STABILITY Thermo- and acid stable; alkali labile [3] .

OTHER REACTIONS Negative $FeCl_3$, periodic acid, xanthate, hydroxamate, Benedict, sodium nitroprusside, ninhydrin, Sakaguchi, Ehrlich; decomposes in 0.1 N NaOH into a yellow product.[2] Infrared: pronounced peaks at 2.88, 3.41, 6.83, 7.29, 8.93 μ; less pronounced at 7.68, 8.37, 10.39, 10.83, 10.96, 12.70 μ; peaks of minimal absorption at 6.05, 11.82, 13.78 μ; deep purple when placed in light at 256 mμ.[3]

/1/ 100°C for 5 minutes. /2/ c, 2.8 absolute ethanol.

104. ELAIOMYCIN (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibits human and bovine strains of Mycobacterium tuberculosis at 0.3-5.0 μg/ml. Other bacteria (including mycobacteria) resistant. Some inhibition of fungi, e.g., Candida spp.[1]

In vivo. No activity against Myco. tuberculosis in mice [1] .

ACUTE TOXICITY LD_{50} in mice, 43.7 mg/kg, i.v.; 62.5 mg/kg, s.c.[1]

105. ENDOMYCIN

SOURCE Streptomyces sp related to S. albus [1] ; S. endus, n. sp [8] .

NATURE Acidic [1] .

MOLECULAR WEIGHT: 1450 (pot. titr.); 1300 (cryo.).[2, 8]

UV ABSORPTION MAXIMA 226, 232 mμ [8] .

SOLUBILITY s. alcohols, methyl cellosolve, water above pH7 and at pH 2 or below[1]; sl. s. dioxane; i. ether, chloroform, benzene, ethyl acetate.[1, 2, 8]

STABILITY Thermostable at pH 7-10 [1, 2, 8] .

OTHER REACTIONS Infrared: 3.0, 3.56, 5.82, 6.04, 6.87, 7.28, 8.81, 9.45, 10.15, 10.97, 11.71, 11.91, 13.90 μ [2, 8] .

QUANTITATIVE DETERMINATION Microbiological: Torula utilis, Candida albicans [1, 2, 8] .

BIOLOGICAL ACTIVITY In vitro. Active against yeasts, fungi, Gram-positive bacteria and protozoa (trypanosomes). No effect on Gram-negative bacteria. Fungi inhibited at 1-25 units/ml: species of Sclerotinia, Torula, Endomyces, Mycoderma, Candida, Trichophyton, Microsporum, Rhizoctonia, Glomerella, Blastomyces, Coccidioides, Geotrichum, Cryptococcus, Histoplasma, and Sporotrichum.[1] Most strains of Candida albicans inhibited by 8-18 μg/ml; C. tropicalis by 6-225 [7] . Concentrations of 25-50 μg/ml suppressed growth of C. albicans in tissue cultures, but even much higher levels were not moniliocidal [9] . Inhibited (μg/ml) Microsporum canis, Epidermophyton floccosum, 1; M. audouini, Trichophyton rubrum, T. schoenleinii, T. acuminatum, T. crateriforme, T. tonsurans, Histoplasma capsulatum, Blastomyces dermatitidis, Cryptococcus neoformans, 6; T. mentagrophytes, M. fulvum, 14-16; Sporotrichum schenckii, >22.[7] Bacteria inhibited at 1-10 units/ml: Micrococcus pyogenes var. aureus, Bacillus cereus, B. subtilis, Brucella abortus, Corynebacterium xerose.. The following required 10->100 units for growth inhibition: Streptococcus faecalis, Aerobacter aerogenes, Escherichia coli, Pseudomonas aeruginosa.[1] Inhibited Trypanosoma cruzi in dilution of 1:12, 800 [3] . Was the most active of 11 antibiotics tested against Trichomonas vaginalis in vitro. In direct tests, T. vaginalis was lysed by concentrations of 50-100 μg/ml.[5]

In vivo. Very slight suppression of Trypanosoma cruzi in mice treated i.p. with injections of 5-10 mg/kg [3] .

ACUTE TOXICITY Mice tolerated doses of 500 mg/kg; 1000 mg/kg were lethal.[1] Inhibited (μg/ml) outgrowth of skin tissue in tissue culture at 250-500, and spleen tissue at 2500-5000 [4] . Chick embryonic heart tissue cultures inhibited by 625-1250 μg/ml [8] . Using roller tube tissue culture method, there was no inhibition of human skin explants by concentrations of 1250 μg/ml [10] .

PHYTOTOXICITY Of low order. Non-toxic when sprayed in concentrations of 10, 000 ppm on wheat, beans, and tomatoes under greenhouse conditions. [5]

RESISTANCE Strains of Candida albicans readily developed resistance in vitro (6 to >45-fold increase when subcultured 11-15 times in presence of antibiotic)[7] .

MISCELLANEOUS Leaf rust of wheat was readily prevented by 100-1000 ppm as spray [6] . Under greenhouse conditions, antibiotic failed to control stem rust of wheat when used as a pre-inoculation spray [11] .

106. ENNIATIN A

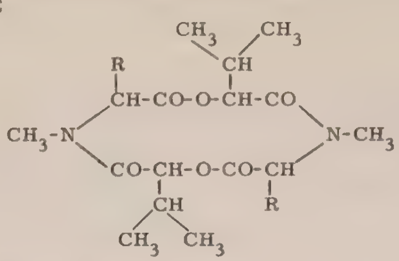
SOURCE Fusarium orthoceras var. enniatinum [1] .

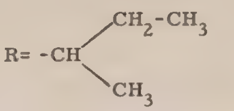
MOLECULAR FORMULA AND WEIGHT $C_{24}H_{42}O_6N_2$ (proposed) [1-3] ; 413-446 (found); 454, 459 (analysis). [1, 3]

/1/ Solubility in water at pH 7 reduced by NaCl, Ca^{++} or Mg^{++}.

106. ENNIATIN A (Concluded)

STRUCTURE





[4]

CRYSTAL FORM AND COLOR Long colorless needles [1-3] .

MELTING POINT (°C) 121-122 [3] .

OPTICAL ACTIVITY $[\alpha]_D = -90$ to -92°[1] [1, 3] .

UV ABSORPTION MAXIMA None characteristic [2, 3] .

SOLUBILITY s. organic solvents; less s. water.[2]

STABILITY Thermostable; alkali inactivated [1-3] .

OTHER REACTIONS Probably identical with lateritiin I; sublimes in vacuo without loss of activity [1-3] .

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium paratuberculosis [1, 3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Myco. tuberculosis, 1:100,000-1:500,000 dilution; Myco. paratuberculosis, 1:1,000,000; Myco. phlei, 1:310,000; Bacillus subtilis, 1:320,000; B. cereus, 1:300,000; B. megatherium, Micrococcus pyogenes var. albus, 1:100,000; M. pyogenes var. aureus, 1:160,000; M. citreus, 1:400,000; Serratia marcescens, 1:80,000. Pseudomonas aeruginosa, Escherichia coli, and Salmonella spp are relatively resistant (<1:1000).[1, 5] Inhibits phytopathogenic fungi (μg/ml): Merulius domesticus, 5; Calonectria nivalis, Helminthosporium gramineum, Coniophora cerebella, Rhizoctonia crocorum, 10; Clasterosporium carphophilum, Lenzites abietina, Polystictus versicolor, Venturia inaequalis, Ophiobolus graminis, Armillaria mellea, 20-50. Activity is decreased by 5-50% in the presence of serum.[5]

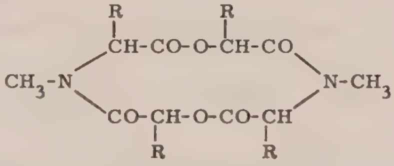
TOXICITY Low toxicity in animals (low solubility precluded high test doses) [5] .

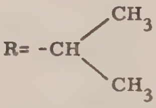
107. ENNIATIN B

SOURCE Same as Enniatin A.

MOLECULAR FORMULA $C_{22}H_{38}O_6N_2$ (proposed) [1, 3] .

STRUCTURE





[2]

MELTING POINT (°C) 173-176 [1, 3] .

OPTICAL ACTIVITY $[\alpha]_D = -106$ to -108°[2] [1, 3] .

SOLUBILITY s. most organic solvents; sl. s. water, petroleum ether.[3]

OTHER REACTIONS Sublimes in high vacuum [3] .

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium paratuberculosis [3] .

/1/ c, about 1 chloroform. /2/ c, 0.63-1.2 chloroform.

107. ENNIATIN B (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Myco. phlei at 3, Myco. paratuberculosis at 5. Activity against bacteria and phytopathogenic fungi weaker than that of Enniatin A.[2]

108. ERYTHROMYCIN

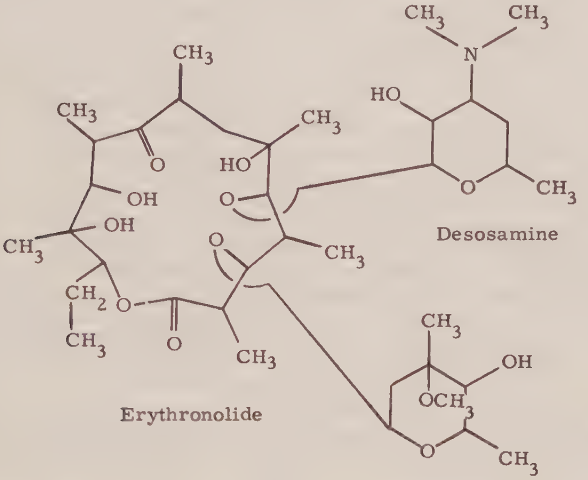
The trademarks for erythromycin are Ilotycin (Eli Lilly & Company) and Erythrocin (Abbott Laboratories).

SOURCE Streptomyces erythreus [1] .

NATURE Basic [1] .

MOLECULAR FORMULA AND WEIGHT $C_{37}H_{67-69}NO_{13}$; 733.9-735.9 (calc.).[5]

STRUCTURE



[84]

CRYSTAL FORM AND COLOR White needles [3, 5] .

MELTING POINT (°C) Base: 136-140[1] [3, 5] . HCl: 170-173. Complex: 82-83.5 (uncorr.) [3] .

OPTICAL ACTIVITY Base: $[\alpha]_D^{25} = -78^{\circ}$[2] [1, 3] . Complex: $[\alpha]_D^{25} = -47^{\circ}$[3] [3] .

UV ABSORPTION MAXIMA Base: 278 mμ [5] . Complex: 274 mμ [3] .

SOLUBILITY s. alcohols, acetone, chloroform, acetonitrile, ethyl acetate; less s. ether, ethylene dichloride, amyl acetate, water. HCl: very s. water, lower alcohols [1, 3, 5] .

STABILITY Stable at -25 to +4°C; stable 4 days at 37°C; unstable to 60 or 100°C.[9]

OTHER REACTIONS One titratable group with pKa 8.6; activity not reduced by serum. Two basic degradation products: amine A ($C_8H_{17}NO_3$) and amine B ($C_7H_{15}NO_2$), the latter obtained by oxidation of amine A. Two acid degradation products: a neutral oil ($C_8H_{16}O_4$) and a crystalline base ($C_{29}H_{49}NO_8$).[1-3, 5] Reduction of erythromycin with sodium trimethoxyborohydride gives dihydro-erythromycin, the infrared spectrum having only 1 carbonyl band at 5.84 μ, with the 5.90 μ infrared and 278 mμ UV bands of erythromycin being lost [49] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Streptococcus pyogenes [1, 8] . Spectrophotometric [10] . Infrared absorption [4] . Colorimetric [6, 7] .

BIOLOGICAL ACTIVITY Active primarily against Gram-positive bacteria; a few Gram-negative organisms, certain rickettsiae and larger viruses are also susceptible.

In vitro. Inhibits most strains of the following at concentrations of 0.003-0.1 μg/ml: Bacillus circulans, B. polymyxa, B. subtilis, Corynebacterium diphtheriae, C. xerose, Lactobacillus casei, Lactobacillus spp, Leuconostoc citrovorum, Mycobacterium avium, Myco. phlei, Sarcina lutea, Streptococcus mitis, Diplococcus pneumoniae. Most strains of the following are sensitive to 0.1-6.2 μg/ml: Actinomyces israeli, B. anthracis, B. brevis, B. cereus,

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/1/ If slow rate of heating continues, it partially resolidifies and then melts at 190-193°C. /2/ c, 1.99 alcohol. /3/ c, 2 ethanol.

Brucella bronchiseptica, Br. melitensis, Br. suis, Hemophilus influenzae, H. pertussis, Listeria monocytogenes, Erysipelothrix rhusiopathiae, Clostridium spp, Lactobacillus arabinosus, M. pyogenes var. aureus, Myco. smegmatis, Neisseria catarrhalis, N. gonorrhoeae, N. meningitidis, Str. pyogenes, Str. faecalis, Streptococcus spp, Gaffkya tetragena, Pasteurella multocida, Vibrio comma. Generally resistant, >50 µg/ml: most strains of Aerobacter spp, Klebsiella pneumoniae, Serratia marcescens, Pseudomonas spp, Salmonella spp, Shigella spp, Proteus spp, Escherichia coli, yeasts and fungi.[1, 9, 11-16] Entamoeba histolytica was inhibited by dilution of 1:8000 [11]. Leptospira icterohemorrhagiae sensitive to 0.001-0.01 µg/ml [50]. Concentrations of 2 mg/ml failed to inactivate the virus of herpes simplex [51]. Active against avian and goat strains of pleuropneumonia-like organisms; strains isolated from sheep were less sensitive.[63]

In vivo. In mice, good protection against infections with Str. pyogenes and D. pneumoniae afforded by 66 mg/kg, s.c., or 133 mg/kg, oral doses; moderate protection against intranasal infections with H. pertussis.[11, 16] Some activity noted in experimental tuberculosis in mice [1, 16]. Daily i.p. doses of 80 mg/kg gave moderate protection in mouse infections with M. pyogenes var. aureus and Listeria monocytogenes, and were ineffective against Ery. rhusiopathiae, B. anthracis and K. pneumoniae; no activity in chicks with experimental fowl typhoid (Salmonella gallinarum) infection.[16] In guinea pigs, s.c. doses as low as 2 mg/kg/da were highly effective against Corynebacterium diphtheriae [15]. High activity in experimental rabbit syphilis, but less active, on a weight basis, than penicillin [17]. Ten daily i.m. doses of 20 mg/kg cured experimental syphilitic orchitis in rabbits [65]. Single i.p. doses in mice of 125 mg/kg, or oral doses of 125-250 mg/kg, gave high protection against Borrelia novyi, moderate protection in experimental toxoplasmosis [1, 18]. Median protective dose against experimental tetanus infection in mice was 11.6 mg/kg/da, given i.p. for 5 days [64]. High oral doses of 200 mg/kg effective in mouse infections with Trypanosoma equiperdum, but inactive against T. cruzi and T. gambiense. Highly effective in clearing rats infected with Entamoeba histolytica; some activity against Trichomonas vaginalis; also suppressed pinworm (Syphacia obvelata) in mice.[1, 18] Daily i.p. doses of 100 mg/kg in mice for 7 days gave 100% protection in infections with psittacosis virus; lower oral doses suppressed infections with lymphogranuloma venereum and meningopneumonitis viruses. High activity against Rickettsia prowazeki in embryonated eggs [11]. Active against R. rickettsi, R. typhi, and R. akari in chick embryos; maximum tolerated doses slightly suppressed Coxiella burnetii [52]. Concentrations of 0.1-0.5 mg/ml in drinking water protected mice against experimental air-borne mouse pneumonitis virus infection [53]. Oral dosage initiated within 2 days of infection protected 80% of guinea pigs against Leptospira icterohemorrhagiae. Renal carriers of this organism were reduced to 10% by continuing medication for 6 days. Similar results were obtained in hamsters.[50] No activity against smaller viruses (rabies, poliomyelitis, lymphocytic choriomeningitis, influenza, Semliki Forest) in mice or guinea pigs [11].

CLINICAL Because of its high order of activity against Gram-positive bacteria, erythromycin is useful in infections caused by these organisms and particularly when strains (e.g., M. pyogenes var. aureus) are resistant to penicillin and the tetracycline antibiotics. Optimal oral dosage not finally established. The average effective dose for adults ranges from 0.2-0.5 g every 6 hours; for children, 6-8 mg/kg doses every 6 hours has been suggested. Pneumonia from D. pneumoniae has responded to initial doses of 0.2 g, with 0.1 g every 3 hours thereafter. In severe infections, doses up to 0.5 g have been repeated every 6 hours [19, 20]. The antibiotic (erythromycin glucoheptonate) may also be administered by the intravenous route [39]. Good results have been obtained in micrococcic enteritis and septicemia caused by strains of M. pyogenes resistant to penicillin and the tetracycline antibiotics [21, 22]. Excellent clinical responses in pneumonia caused by D. pneumoniae and in micrococci and streptococci infections, including pharyngitis, tonsillitis, scarlet fever and cellulitis [9, 23, 24, 33], and has been used with success prophylactically in patients convalescing from rheumatic fever [25]. Favorable, as well as indifferent, results have been reported in preliminary trials in gonorrhea, lymphogranuloma venereum, chancroid and donovanosis [26-30]. In experimental chancroid induced in human volunteers by intradermal injection of cultures of H. ducreyi, topical application of 1% erythromycin ointment 24 hours later prevented the development of lesions [71]. In a small series of patients with primary or secondary syphilis, 200 mg administered 4 times daily rapidly cleared treponemes and reduced the serologic titer [27]. Gonorrheal urethritis successfully treated with single intramuscular doses of 100 or 200 mg [66]. Was of value in therapy of non-gonococcal urethritis; total oral doses of 6.0 g were given over a 5-day period.[69] Good responses in scrub typhus [70]. Favorable results obtained following i.v. therapy in meningitis caused by N. meningitidis and H. influenzae [67]. Total oral doses of 3.2-5.6 g over periods of 4-7 days effectively treated cases of anthrax infection in man [68]. Favorable results in intestinal infections caused by Entamoeba histolytica [37, 54]. Topical use of ophthalmic ointment containing 5 mg/g valuable in the treatment of ocular infections caused by susceptible bacteria [74]. Good clinical responses in trachoma [31], and the antibiotic proved useful in the treatment and prophylaxis of surgical infections [32]. Topical therapy useful in cases of acute pyoderma [34, 35] and in acne vulgaris [36]. Antibiotic therapy failed to influence viral infections of the respiratory tract, including influenza [72, 73]. Little or no effect on the clinical course of pertussis demonstrated in children treated orally with 50 mg/kg/da in divided doses over periods of 4-21 days [55]. Preliminary trials indicate oral medication is effective in actinomycosis [56] and gave good clinical responses in acute and chronic brucellosis [57]. Erythromycin stearate in daily doses of 15 mg/kg for 10-14 days cleared 14 of 15 patients with hepatic amebiasis [58].

VETERINARY Oral medication, or i.v. doses of 50-150 mg, effective in the control of a variety of canine infections, including pneumonia, bronchitis, pyogenic surgical infections, otitis media and early cases of distemper [43, 59-61]. Useful in urinary tract infections of small animals, with usual doses in dogs of approximately 300-1200 mg/da, administered orally in divided doses [59, 60].

108. ERYTHROMYCIN (Concluded)

ACUTE TOXICITY LD_0 in mice, 1000 mg/kg, s.c.; 2000 mg/kg, oral. LD_{50}, approximately 1800 mg/kg, s.c. Doses of 250 mg/kg, s.c. or i.p., were irritating. Oral doses of >100 mg/kg non-toxic to dogs.[1, 15] When administered intratracheally in doses of 5-20 mg/kg in dogs, or in doses of 10-20 mg as an aerosol to guinea pigs, caused bronchopneumonic inflammations which, however, were less severe than those caused by tetracycline antibiotics [75] .

In vitro. In tissue cultures, erythromycin inhibited outgrowth of skin tissue at concentrations of 345-690 μg/ml and spleen tissue at 520-1040 μg/ml [38] .

CHRONIC TOXICITY 5% antibiotic in diet well tolerated in mice, as were daily oral doses of 1.0 g for 2 weeks in dogs. No chronic toxicity in mice receiving daily i.p. or s.c. doses of 700 mg/kg, or in dogs given oral doses of 250 mg/kg/da for 14 weeks.[1, 15, 42] Oral doses for 3-6 days poorly tolerated in guinea pigs and hamsters, with development of diarrhea and anorexia [50] .

In man, toxic symptoms not generally observed with oral doses up to 300-500 mg. Higher doses may cause gastric distress; this was not uncommon in patients receiving 2.0 g every 6 hours [15, 20, 40] . Continued topical use of dermatological preparations, containing 1% of the antibiotic, is associated with a low index of skin sensitization, in contrast to the sulfonamides, penicillin and streptomycin [76] .

RESISTANCE Some strains of M. pyogenes var. aureus developed resistance in vitro with facility; less readily developed by Str. pyogenes.[15, 45] No significant cross-resistance between erythromycin and penicillin or most other antibiotics, with the exception of carbomycin [15, 46-48] . In another series, a high percentage of M. pyogenes var. aureus strains which were resistant to carbomycin were found sensitive to erythromycin [79] . The incidence of infections caused by M. pyogenes var. aureus strains resistant to erythromycin, as well as to other established antibiotics, is increasing [80-82] .

ABSORPTION AND EXCRETION Peak blood levels noted 1 hour after single oral doses in dogs; readily detectable levels in the urine, feces and cerebrospinal fluid.[1] In man, single and multiple oral administration of 0.3-0.5 g produced serum levels of 0.12-2.0 μg/ml in 1 hour, with concentrations as high as 8-16 μg in 3 hours dropping to 0.5-4.0 μg in 9 hours. Therapeutically effective concentrations (0.12 μg) were detected in cerebrospinal fluid, ascitic fluid, and bile, with prolonged excretion at high levels in the urine. The antibiotic traversed the placental barrier.[15] Intravenous preparations administered in single 300 mg doses produced serum levels of 21-82 μg/ml in a few minutes, falling to 2.5 μg in 2 hours and approximately 0.3 μg at the 6th hour. Low spinal fluid concentrations (0.04-0.08 μg) were maintained 2-6 hours after injection. About 15% of the original i.v. dose was excreted in the urine during the first 24 hours.[41] Single or repeated doses of 1% erythromycin lactobionate, injected intrapleurally, were well tolerated in man. A single dose of 250 mg gave high concentrations in pleural fluid and adequate levels in blood for at least 3 days.[62]

MODE OF ACTION Action is bacteriostatic or bactericidal, depending on concentration of the antibiotic and sensitivity of the organism. Active primarily against rapidly multiplying bacteria.[44] Inhibition of C. diphtheriae markedly antagonized by addition to culture medium of β-alanine, calcium pantothenate, or L-carnosine; these substances permitted growth in 30-70 times the original minimal inhibitory concentrations of the antibiotic.[77] In non-bactericidal concentrations, erythromycin, like chloramphenicol and the tetracyclines, inhibited oxidation of glutamic acid in Escherichia coli [78] .

MISCELLANEOUS Solutions containing 1 mg/ml were tolerated for 24 hours by viviparous tropical fish (guppies) [83] .

109. ERYTHROMYCIN B

SOURCE Same as erythromycin [1] .

NATURE Basic [1] .

MOLECULAR FORMULA AND WEIGHT $C_{37}H_{71}NO_{12}$; equiv. wt. 708, 720 (found) [3] ; 736 ± 36 (titr.) [1] .

MELTING POINT (°C) 191-195 [1] ; 202-203 [3] . HCl: 149-150; SO_4: 154-156; hydriodide: 167-169; benzoate: 102-104; ethyl carbonate ester: 117-118; p-(p-hydroxyphenylazo) benzene sulfonate: 165-167; stearate: 54-57.[3]

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = -78^{\circ}$[1] [1] ; $[\alpha]_{D} = -98^{\circ} \pm 1$ [3] .

UV ABSORPTION MAXIMUM 286 mμ [1] .

SOLUBILITY s. ether, acetone, chloroform, ethyl acetate; i. water. Acid salts: s. water. [1]

STABILITY More stable to acid than erythromycin[2] [3] .

/1/ c, 2 ethanol. /2/ Treatment at pH 1.5 of extracted mixture destroys erythromycin and leaves B unchanged.

109. ERYTHROMYCIN B (Concluded)

OTHER REACTIONS Properties very similar to erythromycin from which it can be separated in Craig distribution apparatus [1]. Methoxyl, N-methyl, C-methyl tests positive; on mild acid hydrolysis, cladinose ($C_8H_{16}O_4$) and 2 bases, ($C_{29}H_{55}NO_9$) and ($C_{29}H_{51}NO_8$), are isolated, the former on strong acid hydrolysis yielding desosamine HCl and possibly an α, β unsaturated aldehyde or ketone.[3]

BIOLOGICAL ACTIVITY In vitro. Antimicrobial spectrum similar to that of erythromycin, but B is only approximately 75-85% as active [1].
In vivo. Activity resembles that of erythromycin [4].

TOXICITY Approximately twice as toxic to animals as erythromycin [2].

RESISTANCE Micrococcus pyogenes var. aureus developed resistance to product B somewhat more readily than to erythromycin [4].

ABSORPTION Following oral doses in man, blood levels obtained were approximately twice as high as those following similar doses of erythromycin. After oral doses of 300 mg of erythromycin B, blood concentrations of approximately 5 μg/ml appeared in 2 hours and 0.8 μg in 8 hours.[2]

110. ESPERIN

SOURCE Bacillus mesentericus [1].

CRYSTAL FORM Na salt: needles [2].

MELTING POINT (°C) Na salt: 268-269 (d.). Free acid: 195.[1,2]

SOLUBILITY s. dilute alkali, acetone, chloroform, benzene, acetic acid; i. water.[3]

OTHER REACTIONS Contains DL-leucine, L-aspartic acid, L-valine, and a probable fatty acid, C_{14-16} [1].

BIOLOGICAL ACTIVITY In vitro. Inhibits Mycobacterium tuberculosis in dilution of 1:160,000 [1].

111. ESTIN

SOURCE Penicillium paxilli var. echinulatum [1].

MOLECULAR FORMULA $C_{16}H_{14}O_6Cl_2$ [1].

MELTING POINT (°C) 223-225 [1].

OTHER REACTIONS Contains 2 MeO groups; impure materials contain a second substance, nordin: $C_{18}H_{16}O_8Cl_2$, needles, MP 134-136°C.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus (in dilution of 1:700,000), Sarcina lutea (1:400,000), and Mycobacterium tuberculosis (1:20,000-1:40,000) [1].

112. ETAMYCIN
(Viridogrisein)

SOURCE Streptomyces sp, S. griseus [1,2]; S. griseoviridus [7].

NATURE Amphoteric; weakly basic polypeptide [1,3].

MOLECULAR FORMULA AND WEIGHT $C_{42-43}H_{62-64}N_8O_{11}$ (suggested) [3]; 550 ± 10[1] [1]; 530 ± 10[2] [1]; 816-865, 982 (neut. equiv. found) [3].

CRYSTAL FORM AND COLOR White crystals [1]; white amorphous solid [2].

MELTING POINT (°C) HCl: 163-170 (some decomposition) [1,3].

OPTICAL ACTIVITY $[\alpha]_D^{25}$ = +7.7°[3] [1], +28°[4], +59°[5] [2], -10°[6] [2].

UV ABSORPTION MAXIMA 304 mμ[7], 333-335 mμ[8] [1,2]. Strong end absorption below 250 mμ [1].

SOLUBILITY Base: s. lower alcohols and ketones, chloroform, carbon tetrachloride, carbon disulfide, ethyl acetate, peanut oil, ether, 1 N HCl, 1 N NaOH; sl. s. water[9]; i. petroleum ether. HCl: s. water[10], methanol,

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/1/ Cryoscopic in benzene. /2/ Cryoscopic in dioxane. /3/ c, 2 methanol. /4/ c, 5 absolute ethanol. /5/ c, 5 chloroform. /6/ c, 5 in 50% aqueous ethanol. /7/ Ethanolic or methanolic HCl. /8/ NaOH. /9/ 1 mg/ml. /10/ 4 mg/ml.

112. ETAMYCIN (Concluded)

ethanol, formamide; sl. s. acetone, ethyl acetate, less polar solvents.[1, 2]

STABILITY Very stable at acid and neutral pH; unstable at alkaline.[3]

OTHER REACTIONS C, 60.6, 60.3; H, 7.28, 7.22; N, 12.4, 12.8 [1] . Infrared: Strong bands at 6.05, 6.60, 6.87 μ; moderate bands at 2.93, 3.30, 5.70, 9.5 μ; weak bands at 12.40, 14.35 μ. Brownish-red with $FeCl_3$; weakly positive Folin-Ciocalteu, Baeyer; negative ninhydrin, Sakaguchi; doubtful biuret; acid hydrolysate gives strong ninhydrin; contains threonine, hydroxyproline, alanine, one or more of the leucines; resembles pyridomycin.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Bacillus mycoides, Micrococcus pyogenes var. aureus [1] ; Streptococcus infrequens [4] .

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive and some Gram-negative bacteria; slight activity against certain protozoa, rickettsiae and larger viruses; no activity against fungi. Inhibits (μg/ml) Actinomyces bovis, B. anthracis, B. cereus, Clostridium feseri, Cl. hemolyticum, Cl. novyi, Cl. perfringens, Cl. septicum, Cl. sporogenes, Cl. tetani, Corynebacterium acnes, C. diphtheriae, C. xerose, Erysipelothrix rhusiopathiae, Diplococcus pneumoniae, Lactobacillus acidophilus, M. pyogenes var. aureus, Moraxella bovis, Gaffkya tetragena, Streptococcus agalactiae, Str. dysgalactiae, Str. uberis at 0.04-1.25; Streptococcus sp, Str. pyogenes, B. subtilis, L. casei, 0.63-2.5; Neisseria meningitidis, 1-5; N. gonorrhoeae, Listeria monocytogenes, 5; N. catarrhalis, 2.5; Hemophilus pertussis, 5-10; H. influenzae, 10-50; Mycobacterium tuberculosis, 0.8-6.2; Shigella sonnei, Klebsiella pneumoniae, Proteus vulgaris, 200; Brucella suis, Br. bronchiseptica, Escherichia coli, Malleomyces mallei, Paracolobactrum spp, Salmonella schottmuelleri, S. typhosa, Pseudomonas aeruginosa, Candida albicans, >10->200; pleuropneumonia-like organisms, 6.25; Leptospira icterohemorrhagiae, 33. Protozoa (μg/ml): Entamoeba histolytica, 667; Trichomonas foetus, 2000; Trypanosoma rhodesiense partially inhibited at 250; T. cruzi resistant.[1, 4]

In vivo. Mice protected against D. pneumoniae with i.p. doses of 90 mg/kg, or daily oral doses of 125-400 mg/kg, b.i.d.[1, 4] . Good activity with 200-400 mg/kg oral doses in infections with Str. pyogenes and M. pyogenes var. aureus. Slightly active in mouse infections with H. pertussis, viruses of meningopneumonitis and psittacosis, and in embryonated eggs against Rickettsia prowazeki. Inactive against small viruses and Schistosoma mansoni in mice. Some protection afforded in chicks infected with Plasmodium lophurae.[4] In rats and dogs oral doses of 45-168 mg/kg/da were effective in experimental intestinal amebiasis [6] .

VETERINARY Effective in acute bovine mastitis caused by micrococci or streptococci (some of these cases had not responded to penicillin or streptomycin therapy), following instillation of 250 mg per udder quarter. In preliminary trials, favorable results noted in infectious bronchitis of chickens treated with single oral dose of 250 mg; the same doses also gave good results in kittens with pan-leukemia.[4]

ACUTE TOXICITY LD_{50} in mice, 25-39 mg/kg, i.v.; 125 mg/kg, or >2000 mg/kg, s.c.; >3000 mg/kg, oral. Dogs tolerated single oral doses of 1000 mg/kg; higher doses induced marked leukopenia. Oral LD_{50} in rabbits, >4000 mg/kg.[4, 5]

CHRONIC TOXICITY Mice tolerated 2 daily doses of 100 mg/kg, s.c., for 20 days, or oral doses of 1000 mg/kg/da for 4 days. Hamsters and guinea pigs did not tolerate antibiotic as well as did mice and dogs.[4] Repeated daily oral doses of >250 mg/kg in dogs and cats, but not in rabbits and mice, induced marked leukopenia which subsided soon after drug was withdrawn [5] . Instillation of 250-1000 mg per quarter into bovine udder gave no signs of irritation [4] .

ABSORPTION AND EXCRETION Oral doses of 250-500 mg/kg in mice produced blood levels of 45-50 μg/ml in 1 hour, with no detectable concentration at 3 hours. Peak urine concentrations of 142-830 μg/ml within 2 hours. In dogs, 800 mg/kg oral doses were poorly absorbed.[4] Oral doses of 1000 mg/kg gave blood concentrations of 1-10 μg/ml in 5 hours, with variable distribution in tissues and body fluids; no detectable concentration in cerebrospinal fluid [5] .

113. EULICIN

SOURCE Streptomyces sp resembling S. parvus [1] .

CRYSTAL FORM AND COLOR Helianthate: rosettes. HCl: colorless.[1]

MELTING POINT (°C) Helianthate: 139 [1] .

SOLUBILITY HCl: s. water [1] .

STABILITY HCl: Stable to autoclaving 1 hour at 120°C [1] .

OTHER REACTIONS An actinomycin and a basic substance also produced in culture fluids [1] .

QUANTITATIVE DETERMINATION Microbiological: Aspergillus niger [1] .

113. EULICIN (Concluded)

BIOLOGICAL ACTIVITY In vitro. Primarily active against fungi. Inhibits (μg/ml) A. niger at 0.005; Blastomyces dermatitidis, 0.018-0.037; Alternaria solani, <0.074; Monosporium apiospermum, Histoplasma capsulatum, Cladosporium wernecki, Cryptococcus neoformans, 0.074; Hormodendrum pedrosoi, 0.14; H. compacti, Phialophora verrucosa, 0.28; Bl. brasiliensis, 0.59; Epidermophyton floccosum, 1.2; Trichophyton mentagrophytes, 2.3; Microsporum gypseum, 9.5; Saccharomyces cerevisiae, 35-38.3; Candida stellatoidea, 60.4; C. albicans, C. krusei, 121; Fusarium oxysporum, >38. Bacteria and actinomycetes (μg/ml): Mycobacterium tuberculosis var. hominis, 0.7; Bacillus subtilis, 8.7; Micrococcus pyogenes var. aureus, 17.4; Nocardia asteroides, 2.3. [1, 2] Gram-negative bacteria not sensitive to 25 μg/ml: Escherichia coli, Proteus vulgaris, Salmonella typhosa, Pseudomonas aeruginosa [1] .

In vivo. Active in mice against intraperitoneal infection with Bl. dermatitidis, with median protective daily doses (administered for 10 days) of 0.04 mg/kg, i.p., 0.42 mg/kg, i.m., and 28.6 mg/kg, oral [2] .

PHARMACOLOGY LD_{50} in mice, 3 mg/kg, i.v.; 17 mg/kg, i.p.; 12 mg/kg, i.m.; 46 mg/kg, s.c.[1] Ten daily doses of 8.6 mg/kg, i.p., or 10.1 mg/kg, were toxic in mice (LD_{50}). Preliminary tests in mice indicate that the antibiotic rapidly disappears from the blood within one hour following single i.v. injection [2] .

MODE OF ACTION Fungicidal to Cryptococcus neoformans in vitro in low concentration of 0.25 μg/ml; this was only approximately three times the fungistatic level.[2]

114. EUMYCETIN

SOURCE Streptomyces sp resembling S. purpeochromogenus [1] .

CRYSTAL FORM AND COLOR Colorless fine needles [1] .

MELTING POINT (°C) 148-150 [1] .

UV ABSORPTION MAXIMUM 302 mμ^1 [1] .

SOLUBILITY s. organic solvents; i. or sl. s. water, 10% HCl, 10% NaOH.[1]

OTHER REACTIONS Positive $FeCl_3$, diazo; negative biuret, ninhydrin, Millon, Molisch, Liebermann-Burchard, Sakaguchi, Rosenheim, Fehling; no color with concentrated H_2SO_4, HCl.[1]

QUANTITATIVE DETERMINATION Microbiological: Candida albicans [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Mycoderma sp, Penicillium chrysogenum, <0.05; Trichophyton interdigitale, 0.15; Aspergillus oryzae, 0.32; Willia anomala, 0.5; Oidium lactis, Saccharomyces saké, 1; Rhizopus nigricans, Mucor mucedo, Candida albicans, 10. Actinomycetes: Nocardia mexicana, Streptomyces griseus, <0.05; S. roseoflavus, 0.1; N. asteroides, 1; S. scabies, 5. Bacteria: Mycobacterium tuberculosis, 100; Bacillus subtilis, Micrococcus pyogenes var. aureus, Escherichia coli, >100.[1]

TOXICITY Very toxic in mice; LD_{50}, 2.2 mg/kg, i.p.; 3.0 mg/kg, s.c.[1]

115. EUMYCIN

SOURCE Bacillus subtilis [1] .

SOLUBILITY s. butanol, ethanol, acetone; i. ether, amyl acetate.[1]

STABILITY Thermostable below pH 8 [1] .

OTHER REACTIONS Similar to bacillomycin [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Corynebacterium diphtheriae at 5; Mycobacterium tuberculosis and Myco. avium at 100-300. Slight activity against Micrococcus pyogenes var. aureus. No activity against Escherichia coli, Salmonella spp. Inhibits fungi, 100-300 μg/ml: Trichophyton mentagrophytes, Epidermophyton floccosum and Microsporum gypseum. No activity against Candida and Cryptococcus spp. [1]

In vivo. Inconclusive results in guinea pigs infected with Myco. tuberculosis [2] .

ACUTE TOXICITY Mice tolerated i.v. doses of 250 mg/kg [2] .

116. EUROCIDIN

SOURCE Streptomyces albireticuli, n. sp [2] .

UV ABSORPTION MAXIMA 318, 333, 350 mμ [1] .

/1/ In methanol.

116. EUROCIDIN (Concluded)

SOLUBILITY s. alkali; i. water.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi, 3.1-6.3 μg/ml: Cryptococcus neoformans, Penicillium chrysogenum, Trichosporon beigellii, T. utilis, Candida tropicalis, Saccharomyces saké. Growth inhibition of C. albicans, Sporotrichum beurmanni, and Aspergillus niger at 12.5; Trichophyton mentagrophytes, T. rubrum, 25. Inactive against bacteria: Bacillus subtilis, Escherichia coli, Micrococcus pyogenes var. aureus, Nocardia asteroides.[1] Other investigators report C. albicans, Sac. cerevisiae, and A. niger sensitive to 1.6 μg/ml; Absidia orchidis, 0.4; C. krusei, 3.1; Mucor pusilis, 6.2; Trichophyton interdigitale, 12.5.[3]

ACUTE TOXICITY LD_{50}, i.p. in mice, 22 mg/kg [2] , 36 mg/kg [1] .

117. EXFOLIATIN

SOURCE Streptomyces exfoliatus [1] .

MOLECULAR FORMULA $C_{27}H_{40}O_{16}Cl\cdot H_{20}$ [1] .

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 172 [1] .

SOLUBILITY s. ethanol, acetone, chloroform, ethyl acetate; sl. s. petroleum ether, ether, water.[1]

OTHER REACTIONS Positive Molisch, $FeCl_3$; negative Fehling, Tollens, Liebermann-Burchard.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Diplococcus pneumoniae, Streptococcus pyogenes, Bacillus subtilis, B. anthracis, Corynebacterium diphtheriae and Hemophilus pertussis at 0.3-5.0 μg/ml. With the exception of H. pertussis, Gram-negative bacteria are not sensitive.[1, 2]

ACUTE TOXICITY LD_{50} in mice, 500 mg/kg, s.c.[2]

118. FERMICIDIN

SOURCE Streptomyces sp resembling S. griseolus [1] .

MOLECULAR FORMULA $C_{14}H_{21}NO_4$ [1] .

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 96-97 [1] .

UV ABSORPTION MAXIMUM 290 mμ [1] .

OPTICAL ACTIVITY $[\alpha]_D^{18} = +52.3^\circ \pm 1.5$[1] [1] .

QUANTITATIVE DETERMINATION Saccharomyces cerevisiae [1] .

BIOLOGICAL ACTIVITY In vitro. Active against fungi and protozoa (Trichomonas vaginalis). Inhibits (μg/ml) Sac. formosensis, 0.04; Sac. pastorianus, 0.05; Sac. cerevisiae, 0.4; Torula rubra, 0.2; Candida krusei, 0.5; C. tropicalis, 10; Alternaria kikuchiana, Colletotrichum atramentarium, Phytophthora infestans, 20; Ustilago zeae, 50. Resistant, >100 μg/ml: Aspergillus spp, Penicillium chrysogenum, Mucor mucedo, Trichophyton spp. Protozoa: Trichomonas vaginalis inhibited at 0.2 μg/ml.[1] In other reports, Willia sp sensitive to 0.1; Torula utilis, 0.2; Botrytis sp, 0.8; Aspergillus niger, 1.6; Absidia orchidis, 3.1; Candida albicans, 50; Trichophyton interdigitale, 100.[2]

VETERINARY Daily intravenous doses of 15-25 μg/kg ineffective in the treatment of chronic infectious (viral) anemia in horses [3] .

ACUTE TOXICITY LD_{50} in mice, 180 mg/kg, i.v.; in rats, 2 mg/kg, i.v.[1]

119. FILIPIN

SOURCE Streptomyces filipinensis, n. sp [2, 3] .

NATURE Conjugated polyene; neutral [2] .

MOLECULAR FORMULA AND WEIGHT $C_{30}H_{50}O_{10}$; 571 (calc.).[2]

/1/ c, 0.65 water.

119. FILIPIN (Concluded)

CRYSTAL FORM AND COLOR   Fine feathery needles [2] .

OPTICAL ACTIVITY $[\alpha]_D^{22} = -148.3^{\circ}$[1] [2] .

UV ABSORPTION MAXIMA   355, 338, 322 mμ[2] [2, 3] .

SOLUBILITY   v.s. dimethylformamide, pyridine; s. 95% ethanol, methanol, n-butanol, isopropyl alcohol, tert.-butyl alcohol, glacial acetic acid, ether, ethyl acetate, amyl acetate; i. water, chloroform, 50% ethanol, methylene chloride, Skellysolve B.[2, 3]

STABILITY   Thermolabile; susceptible to autoxidation, especially in light; stable in dark in air at refrigerated conditions; stable in dilute ethanolic solution (50 μg/ml), but unstable at 10 mg/ml under all conditions; deteriorates slowly in methanolic solution at pH 2 and 11.[2]

OTHER REACTIONS   Resembles fungichromin; at 147° changes to a second form which melts at 195-205° (d.); indication of partial degradation in higher form. Infrared (Nujol): bands at 3580, 3360, 1715, 1177, 1137, 1085, 1040, 1005, 840 (recip. cm). Infrared (5% solution in dimethylformamide): bands at 1303, 1160, 1005, 958, 846 (recip. cm). Positive Molisch; negative ninhydrin, Benedict, biuret, Tollens, anthrone, $FeCl_3$, 2, 4-dinitrophenylhydrazine. Degrades in 2 ways, (1) where biological activity and UV maxima disappear simultaneously, and (2) when concentrated methanolic or ethanolic solutions stand at 4°C. In the latter case, a white crystalline substance, without antifungal activity but still a polyene, is formed (probable empirical formula, $C_{30}H_{50}O_{11}$). Deep blue color in concentrated HCl or H_2SO_4, but not in HNO_3.[1, 3]

QUANTITATIVE DETERMINATION   Microbiological: Saccharomyces pastorianus ATCC 2360 [2] . Penicillium oxalicum [2, 3] . UV [2, 3] .

BIOLOGICAL ACTIVITY   In vitro. Active against fungi. Inhibits (μg/ml) Cryptococcus neoformans, 0.95; Candida albicans, Histoplasma capsulatum, Microsporum audouini, Monosporium apiospermum, Sporotrichum schenckii, Trichophyton rubrum, 7.7; Coccidioides immitis, Hormodendrum compactum, Phialophora verrucosa, 15.5; Geotrichum sp, Blastomyces dermatitidis, Nocardia asteroides, 31. Saprophytes and plant pathogens (μg/ml): Gnomonia fragiariae, 0.95; Colletotrichum lindemuthianum, Endothia parasitica, 1.9; Aspergillus niger, P. digitatum, Phoma betae, Phomopsis sp, Thielaviopsis sp, 3.9; Dendrophoma obscurans, Fusarium oxysporum dianthi, Helminthosporium sativum, Sclerotinia sclerotiorum, 7.8; Diplodia sp, Penicillium notatum, 31; Rhizoctonia solani, 500. Yeasts: Sac. pastorianus, Zygosaccharomyces prioranus, 5 μg/ml. Protozoa: Trichomonas foetus sensitive to 25-50 μg/ml. Bacteria not sensitive to 1000 μg/ml: Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Bacillus subtilis, Escherichia coli, Klebsiella pneumoniae, Salmonella typhosa, Proteus vulgaris, Pseudomonas aeruginosa.[3]

PHYTOTOXICITY   Concentrations of 100 μg/ml had no toxic effect upon germination of pea and tomato seeds [3] .

PHYTOPATHOLOGY   Sprays with crude filipin partially protected young tomato plants from gray leaf spot caused by Stemphylium solani [3] . Immersion of pea seeds in the antibiotic prevented development of fungus rot [1] .

MODE OF ACTION   Action against Candida albicans is primarily fungicidal; these cells were non-viable when exposed to concentrations of 10 μg/ml for 7-24 hours or to 50 μg/ml for 2 hours. A greater concentration, or longer exposure period, was required to kill Penicillium oxalicum.[4]

120. FLAVACID

SOURCE   Streptomyces sp resembling S. flavus [1] .

NATURE   Weakly acidic [1] .

CRYSTAL FORM AND COLOR   Yellowish cryst. powder [1] .

MELTING POINT (°C)   102-105 (d.) [1] .

UV ABSORPTION MAXIMA   340, 360, 380 mμ [3] .

SOLUBILITY   s. water, butanol, acetone. Na salt: s. methanol, aqueous acetone, water, ethanol; less s. acetone, butanol; i. ether, ethyl acetate, chloroform, benzene.[1]

STABILITY   Unstable at acid and alkaline pH [1] .

/1/ c, 0.89 methanol. /2/ Shoulder at 305 mμ; in methanol, but does not change in 0.1 N KOH or HCl.

120. FLAVACID (Concluded)

OTHER REACTIONS Serum inactivated; yellowish at neutral pH, green at acid, red at alkaline; precipitates as Ba, Ca, Pb, Zn, or procaine crystalline salts; negative ninhydrin, $FeCl_3$; resembles fungicidin.[1]

QUANTITATIVE DETERMINATION Microbiological: Saccharomyces cerevisiae [1] .

BIOLOGICAL ACTIVITY In vitro. Active against yeasts, fungi, a few bacteria, and also Trichomonas vaginalis. Inhibits (μg/ml) Aspergillus spp, 3-12; Mucor spp, 3; Torula utilis, 1.2; Trichophyton spp, Candida albicans, 0.6-2.5. Bacillus subtilis, B. anthracis and Micrococcus pyogenes var. aureus are sensitive to 3-6 μg/ml.[1] According to another report, Sac. cerevisiae inhibited by 3.1 μg/ml; C. krusei, Botrytis sp, 12.5; Torula utilis, Willia sp, A. niger, 25; Absidia orchidis, Mucor pusilis, 50; Trichophyton interdigitale, 100.[2]

In vivo. Activity against C. albicans infection in guinea pigs. Oral doses of 10 mg cleared the feces of C. albicans.[1]

CLINICAL Was of some value when applied topically in patients with trichophyton infections. Favorable results obtained with tamponades containing 20 mg in Trichomonas vaginalis vaginitis.[1]

ACUTE TOXICITY LD_{50} in mice, 50 mg/kg, i.p.[1]

121. FLAVEOLIN

SOURCE Streptomyces sp [1] .

NATURE Basic [1] .

MELTING POINT (°C) Picrate: 126-128 (d.). Reineckate: 147-150 (d.).[1]

SOLUBILITY HCl: s. water, methanol, ethanol, propanol; sl. s. acetone, benzene, butanol, chloroform; i. ether, petroleum ether, ethyl acetate. Free base: s. butanol, chloroform, iso-amyl alcohol.[1]

STABILITY Fairly stable at pH 2; unstable at alkaline pH at 100°C.[1]

OTHER REACTIONS HCl lemon yellow at acid pH, reddish-brown at alkaline; greenish-blue with Cu acetate in alcohol; positive Liebermann, Pauly; negative Millon, biuret, Sakaguchi, ninhydrin; black color but no precipitate with Fehling; HCl more active at pH 6 than 8; no reduction in activity by glucose, NaCl, serum.[1]

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive and Gram-negative bacteria, yeasts, and fungi. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, Bacillus anthracis, B. subtilis, Streptococcus pyogenes, Diplococcus pneumoniae at 0.025-0.5; Salmonella typhosa, Proteus vulgaris, Shigella dysenteriae, Neisseria meningitidis, Vibrio comma, and Brucella melitensis, 0.05-2.5; Mycobacterium phlei, Myco. smegmatis and Myco. avium at 0.8. Fungi: Aspergillus niger, Mycotorula sp, and Monilia sp inhibited by 3.1-12.5 μg/ml.[1]

ACUTE TOXICITY LD_{50} in mice, 20 mg/kg, i.v. (HCl) [1] .

122. FLUVOMYCIN

SOURCE A strain of Bacillus subtilis [1] .

NATURE Probably a polypeptide; weakly acidic.[1]

FORM AND COLOR White amorphous powder [1] .

SOLUBILITY s. water, aqueous methanol, aqueous ethanol; i. acetone, ether, chloroform, amyl acetate.[1]

STABILITY Stable 2 years at pH 5.5 at 5°C, 1 month at room temperature, 3+ days at pH 2 and 9; destroyed by autoclaving.[1]

OTHER REACTIONS Stable to proteolytic enzymes; readily dialyzable; not precipitated by acids, alkalies.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209; Candida albicans ATCC 10231.

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) M. pyogenes var. aureus, Proteus vulgaris, C. albicans and Torulopsis rotundata at 0.5-1.0; Escherichia coli and Trichophyton mentagrophytes at 33-90. Growth inhibition of other bacteria and fungi at higher concentration.[1]

In vivo. Apparently inactive [1] .

PHARMACOLOGY LD_{50} in mice, 1300 mg/kg, i.v.; 1250 mg/kg, s.c.; 750 mg/kg, i.m. Could not be detected in the blood or urine of dogs and rabbits after i.v. injection.[1]

123. FOMECIN A

SOURCE Fomes juniperinus [1] .

NATURE Weakly acidic [1] .

MOLECULAR FORMULA AND WEIGHT $C_8H_8O_5$; 173, 189 (found); 184 (calc.).[1]

CRYSTAL FORM AND COLOR Depends on solvent [1] .

MELTING POINT (°C) Chars above 160 [1] .

OPTICAL ACTIVITY Inactive [1] .

UV ABSORPTION MAXIMA 241, 305 mμ [1] .

SOLUBILITY Somewhat s. water, ethanol, acetone, ethyl acetate, chloroform; sl. s. benzene.[1]

STABILITY Thermostable at acid and neutral pH; alkali labile.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY *In vitro.* Inhibits (μg/ml) M. pyogenes var. aureus, 8-16; Bacillus subtilis, 31-63; Klebsiella pneumoniae, 63; Escherichia coli, Pseudomonas aeruginosa, 125; B. mycoides, 250; Mycobacterium smegmatis, 250-500. Slight antifungal activity; inhibits Trichophyton mentagrophytes, but no other fungi tested. Possessed antiphage activity.[1] Antiviral activity: Virucidal against influenza virus A in concentration of 500 μg/ml. No activity against strain SK poliomyelitis and eastern equine encephalitis viruses.[2]

ACUTE TOXICITY Mice tolerated doses of >50 mg/kg, i.v. [1] .

124. FOROMACIDINS

SOURCE Streptomyces sp[1] [1] .

NATURE Basic.

MOLECULAR FORMULA AND WEIGHT
Foromacidin A: $C_{54}H_{78}O_{15}N_2$; equiv. wt. 458 (found); MW 887.09 (calc.).
B: $C_{47}H_{80}O_{16}N_2$; equiv. wt. 462, 472 (found); MW 929.13 (calc.).
C: $C_{48}H_{82}O_{16}N_2$; equiv. wt. 478 (found); MW 943.15 (calc.).
D: Equiv. wt. 452 (found).[1]

CRYSTAL FORM AND COLOR Colorless microcrystalline powders [1] .

MELTING POINT (°C) Foromacidin A: 134-138.
B: 130-132.
C: 124-128.
D: 135-140.[1]

OPTICAL ACITIVITY Foromacidin A: $[\alpha]_D = -81°$[2], $-56°$[3].
B: $[\alpha]_D = -83°$[4], $-61°$[5].
C: $[\alpha]_D = -79°$[6], $-62°$[7].
D: $[\alpha]_D = -75°$[8].[1]

UV ABSORPTION MAXIMA Foromacidin A, B, C, D: 231 mμ [1] .

SOLUBILITY s. most organic solvents [1] .

OTHER REACTIONS Infrared maxima include, foromacidin A: 3500, 1725; B: 3500, 1733, 1245; C: 3500, 1733, 1190; D: 3500, 1725, 1245 (recip. cm). Mild acid hydrolysis of A, B, or C yields mycarose, plus forocidin A, B or C; alkaline hydrolysis of foromacidin B and forocidin B yields 1 mole of acetic acid, and foromacidin C and forocidin C 1 mole of propionic acid. An antibiotic active against Gram-negative organisms is also produced in culture fluids.[1]

BIOLOGICAL ACTIVITY *In vitro.* Foromacidin A: Inhibits (μg/ml) Bacillus megatherium, 0.1; Streptococcus mitis, Str. faecalis, 1.0; Corynebacterium diphtheriae, Str. pyogenes, Micrococcus pyogenes var. aureus, 10.

/1/ Resembles S. ambofaciens. /2/ c, 0.34 methanol. /3/ c, 0.52 chloroform. /4/ c, 0.82 ethanol. /5/ c, 0.93 chloroform. /6/ c, 1.19 ethanol. /7/ c, 0.90 chloroform. /8/ c, 0.81 ethanol.

124. FOROMACIDINS (Concluded)

B: Inhibits (μg/ml) Str. mitis, 0.1; Str. faecalis, C. diphtheriae, Str. pyogenes, 1.0; B. megatherium, M. pyogenes var. aureus, 10.

C: Inhibits (μg/ml) Str. mitis, C. diphtheriae, 0.1; Str. faecalis, Str. pyogenes, B. megatherium, 1.0; M. pyogenes var. aureus, 10.

A, B, C: Required 1000 μg/ml or greater for inhibition of Escherichia coli, Salmonella typhosa, S. schottmuelleri, Klebsiella pneumoniae, Vibrio comma, Pasteurella pestis, Shigella sonnei, Pseudomonas aeruginosa, Mycobacterium tuberculosis var. hominis, Candida albicans, and C. tropicalis.

D: Shows about 10% of activity of A, B, C.[1]

In vivo. Five s.c. doses of 1-10 mg/kg gave 50-100% protection against Str. pyogenes in mice; oral doses were also effective. In vivo activity was also demonstrated against infections with M. pyogenes var. aureus, Diplococcus pneumoniae, Pasteurella sp, Borrelia recurrentis, Entamoeba histolytica, and Plasmodium berghei.[1]

TOXICITY Mice tolerated doses of 250 mg/kg, i.v.; 500 mg/kg, s.c.[1]

RESISTANCE Penicillin-resistant organisms were sensitive to foromacidin. Picromycin-resistant strains of M. pyogenes var. aureus showed some cross-resistance to foromacidin.[1]

125. FRADICIN

SOURCE Streptomyces fradiae [1] .

NATURE Weak base [2] .

MOLECULAR FORMULA AND WEIGHT $C_{30}H_{34}N_{4}O_{4}$ (proposed); 500 (Barger); 514.6 (calc.).[2]

CRYSTAL COLOR Light greenish-yellow [2] .

MELTING POINT (°C) 180-300[1] [2] .

OPTICAL ACTIVITY $[\alpha]_{D}^{25} = +65^{\circ}$[2] [2] .

UV ABSORPTION MAXIMUM 290-295 mμ[3] [2] .

SOLUBILITY s. dioxane, chlorinated hydrocarbons, propylene glycol; sl. s. methanol, ethanol, water; i. petroleum ether, cyclohexane, xylene.[1, 2]

STABILITY Thermostable at neutral pH; unstable at acid pH at room temperature.[1]

OTHER REACTIONS From alkali fusion: volatile product giving positive pine splint and Ehrlich's tests for a pyrrol [2] .

QUANTITATIVE DETERMINATION Microbiological: Penicillium notatum [1] .

BIOLOGICAL ACTIVITY In vitro. Active against fungi and protozoa (Entamoeba histolytica). Inhibits Aspergillus niger, Penicillium notatum, Candida albicans, Histoplasma capsulatum, Coccidioides immitis, Fusarium spp, Trichoderma spp, Trichophyton mentagrophytes at 0.12-2.4 μg/ml.[1] Inhibits growth of Entamoeba histolytica at 1 μg/ml. Trypanosoma cruzi inhibited in dilution of 1:100,000 [1, 2] . In vitro activity reversed by reducing agents [3] , and by certain unsaturated fatty acids and Tween 80, but not by saturated, straight-chain fatty acids [4] . Action essentially fungistatic, only weakly fungicidal [3] .

In vivo. No activity against T. cruzi infections in mice [5] .

TOXICITY LD$_{50}$ in mice, 4 mg/kg, i.p., or oral [2] . Renal ischemia observed in mice following sublethal doses. Very irritating to rabbit skin when topically applied in ointment containing 500 μg/g.[2]

126. FRAMYCETIN
(Actiline)

The trademark of Laboratoires Roussel for framycetin is Soframycine.

SOURCE Streptomyces sp resembling S. lavendulae [2] .

MOLECULAR WEIGHT 1400-1500 (found) [1] .

FORM AND COLOR Chlorhydrate: white, amorphous powder [1] .

MELTING POINT (°C) Picrate: 189 (d., corr.) [1] .

/1/ Darkens without melting. /2/ c, 1.0 1,4-dioxane. /3/ Ethanol.

126. FRAMYCETIN (Concluded)

OPTICAL ACTIVITY Picrate: $[\alpha]_D = -32^{\circ 1}$. Chlorhydrate: $[\alpha]_D = +57^{\circ 2}$ [1].

SOLUBILITY Chlorhydrate: s. water, aqueous methanol; i. acetone, ether, most organic solvents.[1]

OTHER REACTIONS No guanidinic grouping; all N as primary amine; forms picrate, reineckate, and p-(p'hydroxyphenylazo) benzene sulfonate. Hydrolysis yields 3 fractions: neamine, a diaminohexose, and a pentose. Resembles streptomycin and neomycin, but differs from both.[1]

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive (including mycobacteria) and Gram-negative bacteria. Low activity against fungi. Inhibits Bacillus subtilis, B. anthracis, Micrococcus pyogenes var. aureus, Salmonella typhosa, S. paratyphi, S. schottmuelleri, Shigella sp, Pasteurella sp, Escherichia coli.[2] Inhibits (μg/ml) strains of M. pyogenes var. aureus resistant to other antibiotics at 0.5-1.0; Proteus spp, Pseudomonas spp, 2-20 [7]; Pr. morgani, Pr. rettgeri, 1-40; Pr. mirabilis, 1-100; Pr. vulgaris, 6-20; Malleomyces pseudomallei, 12.5-25.[4, 5] A majority of 115 strains of Ps. aeruginosa were sensitive to 1-10 μg/ml [6]. Active against strains of Mycobacterium tuberculosis var. hominis which were resistant to streptomycin and isoniazid [8].

CLINICAL Treatment with framycetin in aerosol form gave good results in a majority of patients with a variety of bronchopneumonopathies, e.g., bronchial asthma, pulmonary abscess, acute bronchitis, and suppurative bronchiectasis [9]. Daily oral doses of 2.0 g had a marked suppressive effect (70-99%) on the enteric bacteria, suggesting value as in intestinal antiseptic [7]. Good response noted in patients with staphylococcal infections who received topical applications of framycetin [3].

ACUTE TOXICITY LD_{50} in mice, 65 mg/kg, i.v. Multiple doses of culture filtrate were non-toxic to rabbits, dogs and guinea pigs.[2] In man, total daily oral doses of 0.75-2.0 g were well tolerated [7].

ABSORPTION AND EXCRETION Poorly absorbed from gastrointestinal tract in man [7].

MODE OF ACTION Bacteriostatic and bactericidal [8].

MISCELLANEOUS Exposure to solutions, containing 1 mg/ml, for 8-24 hours was lethal to viviparous tropical fish (guppies) [10].

127. FREQUENTIN

SOURCE Certain strains of Penicillium frequentans [3].

NATURE Aldehyde [1, 3].

MOLECULAR FORMULA $C_{14}H_{20}O_4$ [1].

CRYSTAL FORM AND COLOR Colorless needles [1, 3].

MELTING POINT ($^{\circ}$C) 134.5 (d.) [1, 3].

OPTICAL ACTIVITY $[\alpha]_D^{24} = +82^{\circ 3}$ [1].

SOLUBILITY s. acetone, dioxane, chloroform, ethanol, benzene; sl. s. carbon tetrachloride, water.[3]

OTHER REACTIONS Closely related to palitantin; reddish-purple with $FeCl_3$ in aqueous or alcoholic solution; yields a precipitate with Brady; reduces ammoniacal silver oxide; positive Schiff; no CO_2 from $NaHCO_3$.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Inhibition of germination of Botrytis allii spores [3].

BIOLOGICAL ACTIVITY In vitro. Activity against fungi; only very slight activity against bacteria. Prevents germination of spores of B. allii, Stachybotrys atra, Penicillium gladioli, and Mucor mucedo at 2.5 μg/ml; Absidia glauca and Aspergillus niger at 25-50 μg/ml.[3]

128. FUMAGILLIN

(Phagopedin sigma)

The trademark for fumagillin is Fumidil (Abbott Laboratories), and Fugillin (The Upjohn Company).

SOURCE Aspergillus fumigatus [8].

NATURE Weak monobasic acid [1, 7], or monoester of decatetraenedioic acid [3].

MOLECULAR FORMULA AND WEIGHT $C_{26-27}H_{34-36}O_7$ [3]; 436-488 (found); 472 (calc.).[1, 7]

/1/ c, 0.5 methanol. /2/ c, 1 water. /3/ Chloroform.

128. FUMAGILLIN (Concluded)

STRUCTURE $[C_{16-17}H_{25-27}O_3]$-O-CO-(CH=CH)$_4$COOH [3] .

CRYSTAL FORM AND COLOR Colorless or light yellow crystals [1, 2, 7] .

MELTING POINT (°C) 189-194 (d.) [1, 2, 7] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -26.6^{\circ}$[1] [1, 7] , -24°[2] [2] .

UV ABSORPTION MAXIMA 239, 304, 322, 336, 351 mμ [1, 2, 7] .

SOLUBILITY s. most organic solvents, $NaHCO_3$, dilute alkali; i. saturated hydrocarbons, water, dilute acid.[1]

STABILITY Thermolabile [6] .

OTHER REACTIONS Becomes yellow and properties change on exposure to air for one week; activity loss correlated with loss of spectrophotometric absorptivity at 351 mμ; the tetraenedioic chromophore is destroyed by photolysis of the crystal form in the presence or absence of air; negative $FeCl_3$, Millon, Hopkins-Cole, Fehling, Molisch, Liebermann-Burchard, Legal; forms a methyl ester (MP, 145-147°C), an octabromide (MP, 118-122°C), an amide (chars at 160°C), a dinitrophenylhydrazone (MP, 123-126°C).[1, 4-7]

QUANTITATIVE DETERMINATION Microbiological: Antiphage activity [1, 2] .

BIOLOGICAL ACTIVITY Little or no activity against bacteria and fungi; active against certain protozoa and viruses. In vitro. Inhibits Entamoeba histolytica in dilution of 1:131,000,000 [9] , and Trichomonas vaginalis at 25 μg/ml [10] . Active against bacteriophages [8] . In tissue cultures, antibiotic is virucidal to eastern and western equine encephalitis and slightly active against influenza PR-8 viruses at concentrations of 2.5 mg/ml; inhibition of poliomyelitis (Lansing strain) at 0.5 mg/ml.[11]

In vivo. High activity in experimental amebiasis in monkeys, rats and rabbits. Rats cleared of E. histolytica when treated with oral doses of 11 mg/kg in divided doses for 2 days; in rabbits, complete clearance was obtained with total doses of 100 mg/kg.[9, 12] Slight activity in experimental acute toxoplasmosis (prolonged survival time) in mice [13] . Inactive against mouse infections with Trypanosoma equiperdum, T. gambiense, T. cruzi, or Borrelia novyi [9, 14] . No antiviral activity in mice infected with poliomyelitis (MM strain), influenza A, or swine influenza viruses; inactive in ovo against viruses of herpes simplex or influenza PR-8.[8, 11] Active against nosema disease of bees, arresting the infection during the intracellular phase [15] . Oral doses of 0.02 mg (approximately 0.5 mg/kg) protected chicks against infection with Plasmodium gallinaceum [24] . Daily i.p. doses of 25 mg/kg for 7 days had no inhibitory effect on Ehrlich carcinoma, sarcoma 180, and Krebs-2 carcinoma in mice [27] . Doses of 200 mg/kg/da for 7 days had no effect on RC carcinoma in mice [28]. Single i.p. doses of 50 mg/kg had a slight suppressive effect on Yoshida sarcoma in rats [21] .

CLINICAL Total oral dosages of 50-100 mg, in divided doses over a period of approximately 12 days, cleared majority of human E. histolytica cyst passers [16, 17] . Generally favorable results in extended studies of chronic intestinal amebiasis with optimal oral doses of 10 mg, b.i.d., for approximately 10 days [12, 18] . In other trials, oral regimens of 50-200 mg/da for periods of 9-14 days were reported to be highly effective in intestinal amebiasis, with disappearance of trophozoites and healing of ulcers in all cases [22] . A combined course of fumagillin with tetracycline or erythromycin gave good clinical responses in ulcerative amebiasis, with prompt clearance of E. histolytica [25] .

ACUTE TOXICITY LD_{50} in mice, 800 mg/kg, s.c.; oral doses of 2000 mg/kg tolerated.[1] Chicks tolerated oral doses of 0.3 mg (7.5 mg/kg) [24] . In vitro. Low concentrations (0.012 μg/ml) were toxic to human spermatozoa [19] .

In man, oral doses of 5-10 mg/da for 10-12 days were well tolerated. Following larger doses, abdominal pain and skin rash were frequently noted.[12, 18] A side effect, noted in 2 of 3 patients treated with daily doses of 30-60 mg, was peeling of skin of the palms and soles [23] .

MISCELLANEOUS In concentrations of 1 μg/ml which did not interfere with growth of host Micrococcus pyogenes var. aureus, fumagillin prevented multiplication of staphylophage. There was no action on free phage, but when antibiotic was added during first 15 minutes after the start of the latent period, it prevented phage growth.[26] Feeding of fumagillin to bees increased honey production over 25% [20] .

129. FUMIGATIN

SOURCE Aspergillus fumigatus [1] .

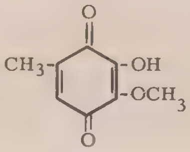
NATURE Pigmented quinone [1] .

MOLECULAR FORMULA AND WEIGHT $C_8H_8O_4$ [1, 2] ; 161 (cryo.); 168 (calc.).[1]

/1/ c, 0.25 methanol. /2/ c, 5 chloroform.

129. FUMIGATIN (Concluded)

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Maroon-colored needles [1, 2] .

MELTING POINT (°C) 116 [1] [2] .

SOLUBILITY s. acetone, ether, chloroform, benzene, ethyl acetate, alcohol, water; sl. s. petroleum ether.[1]

STABILITY Unstable in aqueous solution, especially alkaline [3].

OTHER REACTIONS Can be converted into spinulosin; intense purple-black color in absolute ethanol with one drop of $FeCl_3$; brown changing to cherry red after 2 minutes with cold concentrated H_2SO_4; I from acidified KI; sublimes at high vacuum without decomposition, no reaction with o-phenylenediamine.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Vibrio comma and Sarcina lutea in dilutions of 1:100,000; M. pyogenes var. aureus, 1:1,200-1:200,000; M. pyogenes var. albus, 1:20,000-1:33,000; Bacillus anthracis, 1:33,000-1:50,000; B. subtilis, 1:40,000; Streptococcus viridans, Escherichia coli, 1:1,200-1:12,000.[2, 3]

130. FUNGICHROMIN

SOURCE Streptomyces cellulosae [1] .

NATURE Polyene [1] .

MOLECULAR FORMULA AND WEIGHT $C_{35}H_{60}O_{13}$; 688.8 (calc.).[1]

CRYSTAL COLOR Pale yellow crystals [1] .

MELTING POINT (°C) 205-210 (uncorr.) [1]

UV ABSORPTION MAXIMA 322.5, 338.5, 356.5 mμ [1] .

SOLUBILITY s. methanol, ethanol, butanol, acetone, pyridine, dimethylformamide; i. water, aliphatic hydrocarbons.[1]

OTHER REACTIONS Culture also produces actinomycin; related fungichromatin has similar properties but differs in UV; C, 60.93; H, 8.65; O, 30.42; alkoxyl, <0.1; C-methyl, 8.2; violet changing to blue in concentrated H_2SO_4; slowly reduces Tollens; decolorizes $KMnO_4$ and Br; white waxy solid on hydrogenation; reduced compound inactive biologically and loses characteristic UV. Infrared: 2.36, 3.06, 3.42, 3.54, 5.85, 6.10, 6.30, 6.85, 7.28, 7.48, 8.10, 8.50, 8.79, 9.01, 9.19, 9.39, 9.62, 9, 90, 10.25, 11.17, 11.82, 12.42, 13.10, 13.83 μ.[1]

QUANTITATIVE DETERMINATION Microbiological: Aspergillus niger [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Blastomyces dermatitidis, 0.8; A. niger, 3.2; Candida albicans, Microsporum audouini, 6.3; Trichophyton mentagrophytes, 12.4. The following phytopathogenic fungi are sensitive to 10 μg/ml: Ascochyta linicola, Botryosphaeria ribis, Fusarium oxysporum, Alternaria solani. Fungichromatin, produced by Streptomyces sp, has the same in vitro antimicrobial spectrum as fungichromin.[1]

ACUTE TOXICITY LD_{100} in mice, 16.4 mg/kg, i.p. Oral doses of 1000 mg/kg non-toxic.[1]

131. FUNGISTATIN
(Antibiotic XG)

SOURCE Bacillus sp [2] .

NATURE Amphoteric polypeptide [2] .

MOLECULAR WEIGHT Approximately 2400 [1] .

131. FUNGISTATIN (Concluded)

SOLUBILITY s. methanol, ethanol; i. ether, chloroform, ethyl acetate, dry acetone.[2]

STABILITY Thermostable at acid and neutral pH [2] .

OTHER REACTIONS Gels on standing in water, becoming reversibly inactive; contains lysine, serine, aspartic acid, proline, threonine, alanine, tyrosine, tryptophan, valine, isoleucine, and other amino acids.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Trichophyton gypseum [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi: Candida albicans, Microsporum canis, Cryptococcus neoformans, Rhodotorula sp, Trichophyton sp, Epidermophyton sp at 0.7-11.2 units/ml [2] .

TOXICITY LD_{50} of crude preparations in mice, 50-90 mg/kg, i.v. In vitro. Hemolytic to red blood cells.[2]

UTILIZATION Of 5 antibiotics tested, fungistatin was the most effective in controlling Ascochyta pisi infection (leaf and pod spot) of pea plant; concentration of 25 ppm effective.[3]

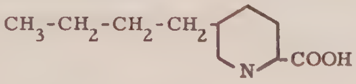
132. FUSARIC ACID
(5-n-Butylpyridine-2-carboxylic acid)

SOURCE Gibberella fujikuroi [1] .

NATURE An acid related to nicotinic acid [1] .

MOLECULAR FORMULA $C_{10}H_{13}NO_2$ [1, 2] .

STRUCTURE



[1, 2]

CRYSTAL FORM AND COLOR Colorless plates [2] .

MELTING POINT (°C) 108-109 [2] .

OTHER REACTIONS Forms a Cu salt with light-violet plates; oxidized to isocinchomeronic acid and propionic acid by $KMnO_4$; distillation of fusaric acid with CaO gives fusarin; oxidation of fusarin with $KMnO_4$ gives nicotinic acid. [2]

BIOLOGICAL ACTIVITY In vitro. Weakly bacteriostatic; inhibits Micrococcus pyogenes var. aureus Salmonella typhosa, Escherichia coli in dilution of 1:2000.[1]

MISCELLANEOUS Preliminary experimental data suggest that fusaric acid may be a vivotoxin implicated in Fusarium wilt of cotton plants [3] .

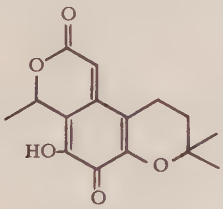
133. FUSCIN

SOURCE Oidiodendron fuscum [1] .

NATURE Quinonoid pigment [1] .

MOLECULAR FORMULA AND WEIGHT $C_{15}H_{16}O_5$ (proposed); 276 (calc.).[2]

STRUCTURE



[4]

CRYSTAL FORM AND COLOR Orange, diamond-shaped plates [1, 2] .

133. FUSCIN (Concluded)

MELTING POINT (°C) 230 [1, 2] .

OPTICAL ACTIVITY Inactive [1, 2] .

SOLUBILITY s. chloroform, acetone, hot ethanol, ethyl acetate, acetic acid, ether, benzene; sl. s. cold ethanol; i. petroleum ether, water.[1, 2]

OTHER REACTIONS Purple color in alkali and aqueous pyridine; red-purple with $FeCl_3$; dihydrofuscin ($C_{15}H_{18}O_5$, MP 206, colorless rhombic crystals) occurs in fuscin filtrates; a stable, active crystalline compound ($C_{17}H_{22}O_8$) is formed with thioglycollic acid.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY Primarily active against Gram-positive bacteria. In vitro. Inhibits (in dilution x 1000) M. pyogenes var. aureus, 80-1280; M. citreus, 1280; Streptococcus pyogenes, Str. viridans, 640; Bacillus anthracis, 320-1280; Corynebacterium diphtheriae, 160-320; B. subtilis, Vibrio comma, 80; Mycobacterium smegmatis, 20; Myco. phlei, Shigella dysenteriae, 10; Proteus vulgaris, Salmonella typhosa, Escherichia coli, 5; Shigella paradysenteriae, Sh. sonnei, Salmonella enteritidis, S. paratyphi, <5.[3]

134. FUSCOMYCIN

SOURCE Streptomyces fuscus [1] .

MELTING POINT (°C) HCl: 180 (d.) [1] .

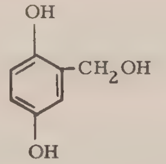
BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus [1] .

135. GENTISYL ALCOHOL

SOURCE Penicillium patulum (Bainier), and other Penicillium spp [1] .

MOLECULAR FORMULA $C_7H_8O_3$ [1, 2] .

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Colorless needles [1, 2]

MELTING POINT (°C) 100-101 [1, 2] .

SOLUBILITY s. water, ethanol, ether; sl. s. benzene, chloroform; i. petroleum ether.[1]

OTHER REACTIONS Decolorizes permanganate; reduces $AgNO_3$; blue color with aqueous $FeCl_3$ changing to yellow; reacts with aqueous I; yellow color with 2 N NaOH, darkening to reddish brown; white amorphous precipitate when heated with 2 N H_2SO_4; sublimes in high vacuum.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

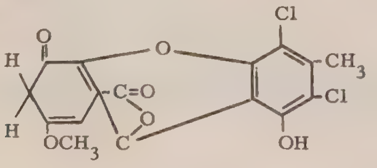
BIOLOGICAL ACTIVITY In vitro. Low activity against M. pyogenes var. aureus: inhibited at 2 mg/ml [1] .

136. GEODIN

SOURCE Aspergillus terreus [1] .

MOLECULAR FORMULA AND WEIGHT $C_{17}H_{12}O_7Cl_2$ [1-4] ; 380 (cryo.).[4]

STRUCTURE



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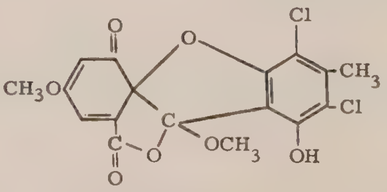


[2]

136. GEODIN (Concluded)

CRYSTAL FORM AND COLOR Brown or yellow needles [2].

MELTING POINT (°C) 227-230; 235 (d.).[3, 4]

OPTICAL ACTIVITY $[\alpha]^{20}_{5461} = +179^{\circ}$[1]; $[\alpha]^{20}_{5790} = +149^{\circ}$[1].[4]

SOLUBILITY s. alcohol, ethyl acetate, chloroform, acetone, dioxane, sodium bicarbonate; sl. s. benzene, ether; i. water, petroleum ether.[4]

OTHER REACTIONS Green to brown color in alcoholic solution with $FeCl_3$; brown-gray precipitate with $FeCl_3$ and neutral Na salt.[4]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [3].

BIOLOGICAL ACTIVITY In vitro. Inhibited (in dilution x 1000) M. pyogenes var. aureus, 8-2000; Bacillus subtilis, 32-1000; M. citreus, Streptococcus pyogenes, 128; B. anthracis, 32-128; Corynebacterium diphtheriae, 23-128; Escherichia coli, 40; Pseudomonas fluorescens, 20; Str. viridans, M. pyogenes var. albus, 8; Mycobacterium smegmatis, 4-20; Vibrio comma, 2; Shigella dysenteriae, 1.[5]

137. GEOMYCINS

SOURCE Streptomyces xanthophaeus, n. sp [1].

NATURE Basic [1, 2].

MOLECULAR FORMULA AND WEIGHT $(C_6H_{12}O_2N_2)_{8-10}$ (proposed). HCl: 1650 ± 165. Free base: equiv. wt. 147 ± 3 (found); 144.2 (calc.).[1, 2]

CRYSTAL FORM AND COLOR Helianthate: red platelets[2]. HCl: amorphous, hygroscopic.[2]

MELTING POINT (°C) Helianthate: 205-215 (d.).[2]

OPTICAL ACTIVITY HCl: $[\alpha]^{20}_{D} = +16.0^{\circ} \pm 0.4$[3] [2].

SOLUBILITY HCl: s. water, methanol; less s. ethanol; i. acetone, ethyl acetate, ether, petroleum ether.[2]

OTHER REACTIONS Positive ninhydrin, Elson-Morgan, nitroprusside-ferricyanide; biuret bright blue; weakly positive Sakaguchi; negative maltol, $FeCl_3$; no change with 2, 4-dinitrophenylhydrazine; both L-β-lysine and a new amino acid (geamine, $C_6H_{12}O_3N_4$) obtained on acid destruction.[1, 3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Escherichia coli [2].

BIOLOGICAL ACTIVITY In vitro. Inhibit M. pyogenes var. aureus in dilution of 1:1,000,000-1:3,000,000, E. coli in 1:210,000-1:500,000. Proteus sp, Klebsiella pneumoniae, Aerobacter aerogenes, Alcaligenes faecalis, Salmonella typhosa, S. paratyphi, and Hemophilus influenzae are also sensitive to a lesser extent. Diplococcus pneumoniae and Streptococcus viridans are not susceptible.[1]

In vivo. Some activity displayed in experimental amebiasis (Entamoeba histolytica) in rats.[1]

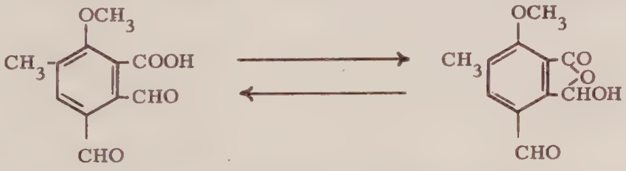
138. GLADIOLIC ACID

SOURCE Penicillium gladioli [1]; by synthesis [7].

NATURE Monobasic carboxylic acid [1, 2].

MOLECULAR FORMULA AND WEIGHT $C_{11}H_{10}O_5$ [1-4]; 212 (Rast); 222.1 (anal.).[1, 2]

STRUCTURE



[2, 4, 5]

CRYSTAL FORM AND COLOR Long, colorless, silky needles [1].

/1/ c, 0.8 chloroform. /2/ From dilute methanol. /3/ c, 3.25 water.

138. GLADIOLIC ACID (Concluded)

MELTING POINT (°C) 160 [1, 2] .

OPTICAL ACTIVITY Inactive [2] .

UV ABSORPTION MAXIMA 275, 343 mμ[1] [2, 3] ; 267, 305 mμ[2] [5] .

SOLUBILITY s. water [5] .

STABILITY Stable at 25°C, pH 3-8; stable to hydrolysis by dilute mineral acids.[1, 2]

OTHER REACTIONS pKa 4.45 at 18°; negative $FeCl_3$, Fehling, Schiff; ammoniacal $AgNO_3$ immediately reduced in cold; intense green color with ammonia solution; no iodoform reaction; readily converted to the slightly active dihydrogladiolic acid.[2, 4]

QUANTITATIVE DETERMINATION Microbiological: Inhibition of germination of Botrytis allii conidia [1, 5] .

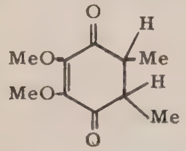
BIOLOGICAL ACTIVITY In vitro. Inhibits spore germination of the following phytopathogenic fungi at 1.9-15.6 μg/ml: Absidia glauca, Fusarium graminearum, F. caeruleum, Penicillium janczewski, P. notatum, P. digitatum, P. expansum, Mucor erectus, Byssochlamys fulva, Verticillium alboatrum, Botrytis allii, and Cephalosporium longisporum. Inhibited, at 62.5-250 μg/ml, Aspergillus flavus, A. niger, Myrothecium verrucaria, Stemphylium sp, Thamnidium elegans, Trichoderma viride, Trichothecium roseum [1, 6] . Bacteria: Micrococcus pyogenes var. aureus inhibited by 250 μg/ml; Escherichia coli and Salmonella typhosa not susceptible to 500.[1]

139. GLIOROSEIN

SOURCE Gliocladium roseum [1] .

MOLECULAR FORMULA AND WEIGHT $C_{10}H_{14}O_4$ [1, 2] ; 188 (Rast); 198 (calc.) [2] .

STRUCTURE



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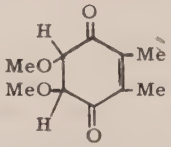


[2]

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 48 [1] .

UV ABSORPTION MAXIMUM 289 mμ [1] .

OTHER REACTIONS No reaction with ketonic reagents; negative $FeCl_3$; does not decolorize Br in glacial acetic acid; reduces Fehling; color produced with tetranitromethane; does not form a quinhydrone.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [1] .

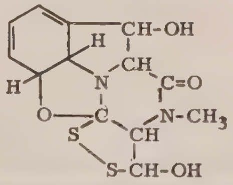
BIOLOGICAL ACTIVITY In vitro. Low activity. Inhibits (μg/ml) B. subtilis, 200; Escherichia coli, 400. The phytopathogenic fungus, Botrytis allii, not sensitive to 400 μg/ml.[1]

140. GLIOTOXIN
(Aspergillin)

SOURCE Aspergillus fumigatus [2] , and several unrelated species of fungi [5, 9, 15] .

MOLECULAR FORMULA AND WEIGHT $C_{13}H_{14}N_2S_2O_4$ [1-3, 5] ; 314 (cryo.); 326 (calc.).[1, 2, 5]

STRUCTURE[3]



(Proposed) [6] .

/1/ 0.1 N NaOH. /2/ Lactol form. /3/ Replacing S atoms with H gives dethiogliotoxin.

140. GLIOTOXIN (Concluded)

CRYSTAL FORM AND COLOR Colorless, elongated plates or needles [1, 3] .

MELTING POINT (°C) 195 (d.) [1-3] .

OPTICAL ACTIVITY $[\alpha]_D$ =-239 to -256°[1] [2] ; $[\alpha]_D^{25}$ = -290° ± 10 [2] [5] .

UV ABSORPTION MAXIMUM 270 mμ [2] .

SOLUBILITY s. acetic acid, acetone, acetonitrile, tert.-butanol, carbon tetrachloride, chloroform, dioxane, dimethylformamide, ethyl acetate, ethyl bromide, HCl, methanol, pyridine; sl. s. water, benzene, ethanol.[5]

STABILITY Acid stable, alkali unstable; unstable to light.[1]

OTHER REACTIONS Readily oxidized with S, forming sulfates; yields H_2S when reduced; plack precipitate with lead acetate in boiling alkali; in alkaline solution decolorizes $KMnO_4$, giving a green color.[4]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus; Rhizoctonia solani; inhibition of germination of Botrytis allii spores.[1, 2, 4]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) M. pyogenes var. aureus, M. pyogenes var. albus, Streptococcus viridans, Hemophilus pertussis, Neisseria catarrhalis, Salmonella typhosa, S. paratyphi, 0.2-5.0; S. schottmuelleri, Escherichia coli, 10.[5] Corynebacterium diphtheriae, N. meningitidis, Str. pyogenes, and Diplococcus pneumoniae also sensitive to low concentrations; Proteus vulgaris and Pseudomonas aeruginosa are resistant.[1, 3] Human and bovine strains of Mycobacterium tuberculosis sensitive to 0.02-0.06 μg/ml [7] . Fungi: Inhibited (in dilution of 1:250,000-1:1,000,000) Trichophyton rubrum, T. purpureum, Microsporum canis, Epidermophyton floccosum, Candida stellatoidea. T. tonsurans, T. gypseum, M. audouini, C. albicans, C. krusei, C. tropicalis inhibited by 1:20,000-1:100,000 [5, 8, 12] ; Blastomyces dermatitidis at 1:2000-1:8000 [5] . Phytopathogenic fungi: Ascochyta pisi, Botrytis allii, Rhizoctonia solani, Sclerotinia americana inhibited by 1:300,000-1:450,000; Ceratostomella ulmi by 1:12,000.[9-11, 16] Inactivation of Gardner lymphosarcoma and various transplantable carcinomas of mice and rabbits by exposure to 1-25 μg/ml [7] . Sarcoma 180 implants rendered almost completely innocuous in mice by exposure to 1 mg/ml [13] .

In vivo. No protection in mice against infection with Str. pyogenes [1] . Daily oral doses up to 6.2 mg/kg gave no protection in experimental mouse tuberculosis [7] . Daily i.p. doses up to 3 mg/kg had no inhibitory effect on RC carcinoma or sarcoma 180 in mice [17, 18] . Post-treatment in mice failed to suppress implants of sarcoma 180 [13] .

TOXICITY LD_{100} in mice, 45-65 mg/kg, i.p., s.c., or oral; in rabbits, 45-65 mg/kg, i.v. [1, 5] .

PHYTOPATHOLOGY Good control in covered smut of barley and bunt of wheat when used as seed protective [11] . Failed to control stem rust of wheat when used as pre-inoculation spray under greenhouse conditions [19] . High protective action against infections with the fungus Cercospora nicotiniae in tobacco leaves, with low toxicity to these plants [14] .

141. GLOBICIN

SOURCE Strain of Bacillus subtilis [1] .

SOLUBILITY s. water at neutral and alkaline pH; i. water at acid pH, organic solvents.[1]

STABILITY Thermostable at pH 2.0-8.5[3] [1] .

OTHER REACTIONS Precipitates with $(NH_4)_2SO_4$; adsorbed on asbestos-pad filters; no hemolysis; activity decreased in presence of Albumin V (Armour); contains tryptophan and loosely bound S, but no tyrosine; no blue color with $FeCl_3$.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, B. subtilis, B. cereus, Mycobacterium avium, and Myco. phlei at 10 μg/ml or less. Gram-negative organisms resistant.[1]

142. GLUTINOSIN

SOURCE Metarrhizium glutinosum [1] .

MOLECULAR FORMULA AND WEIGHT $C_{48}H_{60}O_{16}$ (proposed); 920, 755 (Rast); 892.7 (calc.).[1]

CRYSTAL FORM AND COLOR Thin colorless plates [1] .

/1/ Chloroform. /2/ c, 0.078 ethanol. /3/ 120°C for at least 30 minutes.

142. GLUTINOSIN (Concluded)

MELTING POINT (°C) Darkens but does not melt at 300 [1] .

OPTICAL ACTIVITY $[\alpha]_D^{20}$ = approximately $+54^{\circ 1}$ [1] .

SOLUBILITY s. chloroform, ether, n-butanol, petroleum ether, ethanol, cyclohexane, benzene; sl. s. water. [1, 2]

STABILITY Thermostable at acid pH; less so above pH 7 [1, 2] .

QUANTITATIVE DETERMINATION Microbiological: Botrytis allii spore germination [1, 2] .

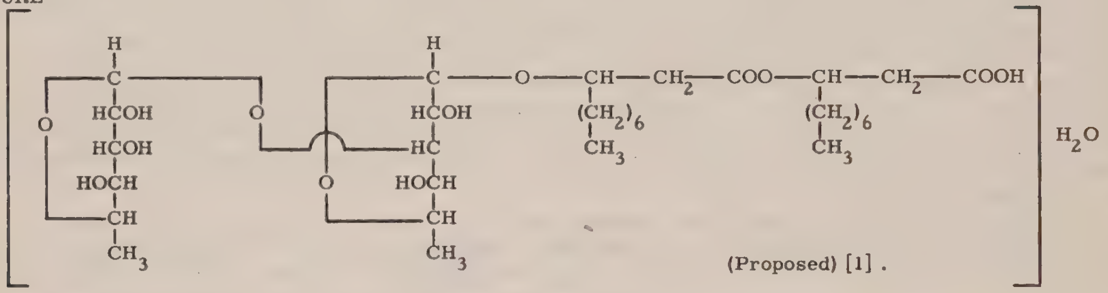
BIOLOGICAL ACTIVITY In vitro. Inhibits phytopathogenic fungi: B. allii, Penicillium digitatum, Phoma betae, Phytophthora palmivora, Mucor mucedo, Thamnidium elegans, Byssochlamys fulva, 1-25 μg/ml. M. erectus, Chaetomium globosum, Gibberella saubinetii, Fusarium coeruleum insensitive to 100 μg/ml.[2]

143. GLYCO-LIPIDE
(l-β-Hydroxydecanoic acid)

SOURCE Pseudomonas aeruginosa [1] .

MOLECULAR FORMULA AND WEIGHT $C_{32}H_{60}O_{14}$; 665 (neut. equiv.); 650 (Rast).[1]

STRUCTURE



(Proposed) [1] .

CRYSTAL FORM AND COLOR Thin, colorless rectangular platelets [1] .

MELTING POINT (°C) 86 [1] .

OPTICAL ACTIVITY $[\alpha]_D = -84^{\circ 2}$ [1] .

SOLUBILITY s. ether, ethyl acetate, acetone, dioxane, dilute $NaHCO_3$; i. water, petroleum ether.[1]

OTHER REACTIONS Positive Molisch; negative Fehling; undergoes acid hydrolysis; a loss of weight equivalent to 1 water molecule per mole of acid occurs upon heating under reduced pressure to 60° for 24 hours.[1]

QUANTITATIVE DETERMINATION Spectrophotometric [2] .

BIOLOGICAL ACTIVITY In vitro. Strains of Mycobacterium tuberculosis var. hominis inhibited by concentration of 500 μg/ml [1] .

ACUTE TOXICITY I.p. doses of 250 mg/kg lethal to mice [1] .

144. GRAMICIDIN
A component of tyrothricin (q.v.).

SOURCE Bacillus brevis [1] .

NATURE Neutral polypeptide [1, 8] .

MOLECULAR FORMULA AND WEIGHT Possibly $C_{148}H_{210}O_{26}N_{30}$ [8] ; 1000-3000 (found); 2826 (calc.).[1, 6, 8]

CRYSTAL FORM AND COLOR Colorless platelets with pointed or rectangular ends [1, 3, 8] .

MELTING POINT (°C) 228-231 [1-3, 8] .

/1/ c, 0.2 benzene. /2/ c, 3 chloroform.

144. GRAMICIDIN (Concluded)

OPTICAL ACTIVITY $[\alpha]^{20}_{D}$ = +3°[1] [9] .

UV ABSORPTION MAXIMA 281.5, 290.5, 271 mμ [8] .

SOLUBILITY s. lower alcohols, acetic acid, pyridine, wet acetone, dioxane; sl. s. absolute acetone; i. water, ether, hydrocarbons, chlorinated hydrocarbons.[1, 3, 8]

STABILITY Thermostable [1] .

OTHER REACTIONS Composed of 3 closely related substances: A fraction contains L-tryptophan, D-leucine, L-alanine, DL-valine, glycine; B fraction same plus phenylalanine; C fraction same as A plus tyrosine; negative Millon; positive to most common protein tests; hydrolyzed by acid; not digested by enzymes; forms a gel with picric acid.[2, 3, 7, 8]

Treatment of gramicidin with HCHO yields argicillin (hydroxymethyl gramicidin), MP 265; soluble in water (2.6 mg/100 ml), ethanol, acetone, glycols; thermostable [25] .

QUANTITATIVE DETERMINATION Microbiological: Streptococcus spp, Micrococcus conglomeratus [2, 4, 9] ; Str. faecalis ATCC 10541 [26] . Colorimetric (for tyrothricin) [5] .

BIOLOGICAL ACTIVITY Primarily active against Gram-positive bacteria. In vitro. Inhibits (μg/ml) Diplococcus pneumoniae, 0.1-20; Str. pyogenes, 1-50; Group D streptococci, 0.2; Str. faecalis, 40-200; M. pyogenes var. aureus, 5-5000; M. lysodeikticus, 0.03; Sarcina lutea, 3; Gaffkya tetragena, 0.6; Lactobacillus spp, Corynebacterium spp, 50-500; Clostridium spp, 20-500; Mycobacterium tuberculosis, 20-50; Neisseria catarrhalis, 20; N. gonorrhoeae, 20-10,000; N. meningitidis, 40-10,000; Brucella abortus, 100. Escherichia coli, Salmonella typhosa, Salmonella spp, Shigella spp, Aerobacter aerogenes, Bacillus anthracis, B. mycoides, B. mysentericus, >300; Actinomyces spp, 300.[8, 11] Protozoa: Leishmania tropica, Trypanosoma cruzi, and T. lewisi insensitive to 1 μg/ml[12] . Argicillin inhibits (μg/ml) D. pneumoniae, 0.012-0.05; M. pyogenes var. aureus, 0.4-0.6; Str. pyogenes, 10-15; N. catarrhalis, 15-20; E. coli, 200.[25]

In vivo. Single i.p. doses of 8-16 μg protected mice against infections with Str. pyogenes [13] , and doses as low as 2 μg gave high protection against D. pneumoniae [1, 10] . Active against mouse infections with B. anthracis, M. pyogenes var. aureus, and Cl. perfringens [13, 14] , and in chicks infected with Plasmodium gallinaceum [15] . Little or no protection when injected by s.c., i.m., i.v., or oral routes [8] .

CLINICAL Reports of clinical and veterinary usage deal mainly with tyrothricin (q.v.). Parenteral toxicity of gramicidin (or tyrothricin) precludes use in systemic infections. Beneficial effect of gramicidin reported in minor oral disorders when combined with bacitracin in troches for topical administration.[16]

VETERINARY Intrammamary instillation of purified preparations of value in therapy of bovine mastitis [8, 22] .

ACUTE TOXICITY LD_{100} in mice, 2.5-5.0 mg/kg, i.v.; 60 mg/kg, i.p. Oral doses as high as 1000 mg/kg non-toxic to mice and rats.[8, 17] Marked induration at site of s.c. injection of 200 μg in rabbits [20] . In vitro. Hemolytic activity less than that of tyrocidin, but low concentrations (0.5-1.0 μg/ml) slowly lysed red blood cells; this was counteracted by high concentrations (2 mg/ml) of glucose.[10] In tissue cultures, concentrations of 100 μg/ml non-toxic to leukocytes [19] ; no inhibition of phagocytic activity of leukocytes at 2000 μg/ml [20] . Cattle spermatozoa immobilized by 10 μg/ml [18] .

Argicillin: 0.1 mg/kg, i.v., lethal to mice. In vitro. Hemolytic activity of argicillin against rabbit erythrocytes is approximately 1/4 that of gramicidin [25] .

CHRONIC TOXICITY Daily i.v. doses of approximately 2 mg/kg were lethal to mice, rabbits and dogs. Sublethal doses induced progressive anemia, hematuria, ascites and severe degenerative changes in the viscera.[17, 20]

RESISTANCE Many strains of M. pyogenes var. aureus readily acquired resistance in vitro [23] .

MODE OF ACTION Primarily bacteriostatic, but low concentrations may be bactericidal; activity is depressed by phospholipids of the cephalin type [10] , and cationic detergents [24] . Gramicidin resembles the latter in its effect upon surface tension and also in precipitation of proteins [3] . Sub-bacteriostatic concentrations of 40 μg/ml inhibit production of capsular material (polysaccharide) by Klebsiella pneumoniae [21] . Prevents uptake of phosphate but not O_2 by M. pyogenes; this failed to occur in yeast cells [8] .

145. GRAMICIDIN J

SOURCE Bacillus brevis [1] .

NATURE Cyclic heptapeptide [1] .

MOLECULAR WEIGHT Approximately 800 [1] .

/1/ c, 0.17 95% ethanol.

145. GRAMICIDIN J (Concluded)

OTHER REACTIONS Contains 1 D-phenylalanine, 1 L-phenylalanine, 1 D-leucine, 1 L-ornithine, 1 D-ornithine, 1 L-valine, 1 L-proline [1] .

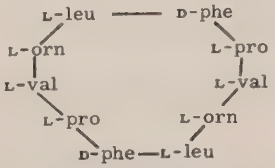
146. GRAMICIDIN S

SOURCE Bacillus sp, similar to B. brevis [1] .

NATURE Cyclic decapeptide [6] .

MOLECULAR WEIGHT 1060-1340 [2, 3] ; 1, 248 (X ray) [5] .

STRUCTURE



[6]

CRYSTAL FORM AND COLOR Thin colorless needles [1] .

MELTING POINT (°C) 268-270 [2] .

OPTICAL ACTIVITY $[\alpha]^{18}_{D} = -292^{\circ}$[1]; $[\alpha]^{20}_{D} = -295^{\circ}$[1].[4, 5]

SOLUBILITY s. aqueous ethanol, chloroform, acetone; less s. absolute ethanol; i. water, acids, alkalies.[2]

STABILITY Thermo- and acid stable [1] .

OTHER REACTIONS Positive ninhydrin (deep blue color but no evolution of CO_2), biuret; negative xanthoproteic, Millon, Pauly, Voisenet, Sakaguchi.[2] Some copolymers are antibiotically active [9] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, Streptococcus spp, Diplococcus pneumoniae, 10; Clostridium perfringens, Cl. histolyticum, 7. Also active against Gram-negative bacteria (μg/ml): Shigella dysenteriae, 12; Vibrio comma, Escherichia coli, 25; Salmonella paratyphi, Salmonella spp, 50; Proteus vulgaris, 100.[7]

In vivo. Doses of 400 μg gave good protection in guinea pigs infected with Cl. perfringens [7] .

CLINICAL Used topically (400 μg/ml solution) in skin infections, empyema, osteomyelitis and peritonitis with favorable results [8] .

TOXICITY LD_{50} in rats, 17 mg/kg [1] . In man, solutions of 400-800 μg/ml were non-toxic when topically applied to the skin [7] .

147. GRANEGILLIN

SOURCE Aspergillus sp resembling A. flavus [1] .

NATURE Resembles aspergillic acid [1] .

MOLECULAR FORMULA $C_{12}H_{20}N_2O_2$ [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Shigella spp, and Salmonella spp; Proteus vulgaris, Pseudomonas aeruginosa and Gram-positive bacteria are less sensitive.[1]

In vivo. Protection observed in mice infected with Salmonella typhosa and Klebsiella pneumoniae [1] .

ACUTE TOXICITY LD_{50} in mice, 100-150 mg/kg, i.p.; 280-320 mg/kg, oral.[1]

148. GRASSERIOMYCIN

SOURCE Streptomyces lavendulae [1] .

COLOR HCl: faint yellow [1] .

MELTING POINT (°C) Helianthate: 215-225 (d.). Reineckate: 187-190 (d.).[1]

/1/ c, 1.5 ethanol.

148. GRASSERIOMYCIN (Concluded)

SOLUBILITY HCl: s. water, methanol; i. most organic solvents.[1]

OTHER REACTIONS Resembles streptothricin in most reactions, but differs in a few. Reactions of 10 mg/ml, aqueous HCl solution: positive Molisch, Fehling, Tollens, ninhydrin; negative biuret, Sakaguchi, xanthoproteic, Millon, Adamkiewicz, Liebermann, Neubauer, $FeCl_3$.[1]

QUANTITATIVE DETERMINATION Microbiological: Virus of silkworm jaundice in silkworms [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Mycobacterium tuberculosis, Myco. phlei, Bacillus subtilis, Micrococcus pyogenes var. aureus, Pseudomonas fluorescens, Escherichia coli, Aspergillus oryzae, A. niger, Penicillium chrysogenum, and Saccharomyces cerevisiae. Trichophyton interdigitale, Torula utilis and Candida albicans are not sensitive. Strains of E. coli resistant to streptothricin, neomycin and grisein were not sensitive to grasseriomycin.[1]

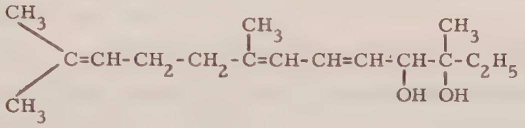
In vivo. Active against the virus of silkworm jaundice. When injected s.c., protection was afforded in artificially infected silkworm pupae.[1]

149. GRIFOLIN

SOURCE Grifola confluens [1] .

MOLECULAR FORMULA AND WEIGHT $C_{16}H_{28}O_2$; 250 (found); 252 (calc.).[1]

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Fine colorless crystals [1] .

MELTING POINT (°C) 40 [1] .

UV ABSORPTION MAXIMUM 275 mμ[1] [1] .

SOLUBILITY s. most organic solvents; i. water. [1]

STABILITY Thermostable; fairly stable to acid and alkali [1] .

OTHER REACTIONS In increasing alkaline concentration, a purple-red color; resinifies when heated in 10% alkaline solution.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus in dilution of 1:200,000; B. subtilis, 1:180,000; B. anthracis, Salmonella typhimurium, Shigella dysenteriae, 1:10,000; Mycobacterium avium, Myco. phlei, 1.5000.[1]

TOXICITY LD_{100} in mice, 1600 mg/kg [1] .

150. GRISAMINE

SOURCE Streptomyces sp resembling S. griseoflavus [1] .

MOLECULAR FORMULA AND WEIGHT $C_{28}H_{38}N_6O_{10}$; 603.24 (calc.); 604.546 (Rast); or $C_{20}H_{30}N_4O_7$.[1]

CRYSTAL FORM Needles [1] .

MELTING POINT (°C) Free grisamine: 165-170. SO_4: 175-180.[1]

UV ABSORPTION MAXIMA 255, 320 mμ[2] [1] .

SOLUBILITY s. water, ethyl acetate, butanol, chloroform; sl. s. ether; i. petroleum ether, benzene, toluene, ligroin.[1]

/1/ Complete transmission above 300 mμ. /2/ Water.

150. GRISAMINE (Concluded)

OTHER REACTIONS Negative ninhydrin, biuret, Fehling, Sakaguchi, $FeCl_3$; weakly positive p-dimethylaminobenzaldehyde, sodium nitroprusside.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis var. hominis, 4-13; Myco. phlei, 8; B. subtilis, 30; Micrococcus pyogenes var. aureus, 70. Not sensitive: Escherichia coli, Pseudomonas aeruginosa, yeasts and fungi.[1]

ACUTE TOXICITY Mice tolerated 150 mg/kg, i.v.; 160 mg/kg caused delayed deaths.[1]

151. GRISEIN

SOURCE Certain strains of Streptomyces griseus [1] .

NATURE Weak acid [3] .

MOLECULAR FORMULA AND WEIGHT $C_{40}H_{61}O_{20}N_{10}SFe$; 1034 (found); 1090 (calc.).[3]

CRYSTAL FORM AND COLOR Red amorphous powder [3] .

ABSORPTION MAXIMA 265, 420 mμ [3] .

SOLUBILITY s. water, phenol; sl. s. acetone, 95% ethanol; i. ether, chloroform, absolute ethanol, absolute ether.[1-3]

STABILITY Stable at 100°C for 10 minutes; inactivated by methanolic HCl [1-3] .

OTHER REACTIONS Not affected by cysteine, sodium thioglycollate, hydrazine, hydroxylamine, semicarbazide; forms amorphous picrate, but no helianthate or reineckate, negative Brady, Fehling, Tollens, Liebermann phenol; no formation of furfural; no free C=S or =CSH groups; Fe may be removed from and re-added to molecule.[2, 3]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli (especially streptomycin-resistant strains) [1, 2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Bacillus subtilis, Micrococcus pyogenes var. aureus, Sarcina lutea, Mycobacterium tuberculosis, Myco. phlei, Aerobacter aerogenes, Klebsiella pneumoniae, Pseudomonas aeruginosa, Serratia marcescens, Salmonella pullorum, Shigella spp, E. coli, Salmonella spp. Streptomycin-resistant strains of E. coli were sensitive to grisein. Fungi not sensitive.[1, 2] In vitro resistance was readily developed by some organisms [1] .

In vivo. Protection afforded mice infected with M. pyogenes var. aureus and Salmonella schottmuelleri [2] .

TOXICITY Parenteral doses of 500,000 units/kg tolerated by experimental animals [2] . Mice tolerated parenteral doses of 500 mg/kg [4] .

152. GRISEOFLAVIN

SOURCE Streptomyces griseoflavus [1] .

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 210-215 (d.) [1] .

SOLUBILITY s. methanol, ethanol, propanol, phenol, acetic acid, hot acetone, alkaline water; sl. s. water, ethyl acetate, butyl acetate; i. ether, petroleum ether, benzene, trichloroethylene, chloroform. [1]

OTHER REACTIONS Not precipitated with picric acid, flavianic acid, methyl orange; negative biuret, ninhydrin, Millon, Sakaguchi, Molisch, glucosamine, $AgNO_3$ reduction, Fehling, $FeCl_3$, triphenylmethane; more active at acid pH.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Bacillus subtilis PCI-219 [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) M. pyogenes var. aureus, 0.2-3.1; B. anthracis, 3.1; Vibrio comma, 0.8; Mycobacterium tuberculosis, 2.0; B. subtilis, 25; Shigella sonnei, 50; Diplococcus pneumoniae, 25-50; Neisseria meningitidis, 100; Mycobacterium spp, 25-400.[1]

TOXICITY LD_{50} in mice, >250 mg/kg, i.p. [1] .

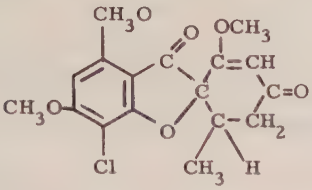
153. GRISEOFULVIN

SOURCE Penicillium griseofulvum [1] , and other Penicillium spp [8] ; P. urticae (Bain), P. nigricans [12] ; P. raistrickii [13] .

NATURE Neutral [1] .

MOLECULAR FORMULA AND WEIGHT $C_{17}H_{17}O_6Cl$ [1, 4, 6] ; 309-398 (found); 352.5 (calc.).[1, 3]

STRUCTURE



[5, 6]

CRYSTAL FORM AND COLOR Massive colorless rhombic or octahedral crystals [1, 3] .

MELTING POINT (°C) 218-221 [1, 3, 4, 6] .

OPTICAL ACTIVITY $[\alpha]^{19}_{5790} = +354^{\circ}$[1] [1] ; $[\alpha]^{17}_{D} = +370^{\circ}$[2] [3] ; $[\alpha]^{19}_{5461} = +417^{\circ}$[1] [1] ; $[\alpha]^{21}_{D} = +337^{\circ}$[3] [4] .

UV ABSORPTION MAXIMA 286, 325 mμ [6] .

SOLUBILITY s. NN'-dimethylformamide 12-14% at room temperature [11] , acetic acid, dioxane, benzene, ether, ethanol; sl. s. chloroform, ethyl acetate, toluene, acetone, ligroin; i. water, petroleum ether. [1, 3]

STABILITY Thermostable [2] .

OTHER REACTIONS Negative $FeCl_3$, HBr, alkaline sodium nitroprusside, pyridine; yellow color with H_2SO_4 or HNO_3; reacted with phenylhydrazine and 2, 4-dinitrophenylhydrazine, but not with diazomethane or semicarbazide; bromo-analogue can be made by replacing KCl in culture medium with KBr.[1, 7] Can be precipitated with water from concentrated solutions of dimethylformamide to yield fine dispersions; solutions in above solvent up to 1% can be diluted with water without precipitating.[11]

QUANTITATIVE DETERMINATION Microbiological: Curling of hyphae and stunting of germ tubes of Botrytis allii [2] . Spectrophotometric [11, 14] . Isotope dilution [11, 15] . Polarimetric [11] .

BIOLOGICAL ACTIVITY In vitro. Shows antifungal activity. Inhibits numerous species of zygomycetes, ascomycetes (except Saccharomyces cerevisiae), basidiomycetes, and Fungi imperfecti at 20 μg/ml or less.[8]

PHYTOTOXICITY In general, toxic to angiosperm seeds at 25 μg/ml; low toxicity in wheat, clover, and mustard seedlings.[8, 10] Concentrations of 5 μg/ml toxic to wheat plants and tended to accumulate in the leaves [17] .

PHYTOPATHOLOGY Did not increase the resistance of wheat seedlings to infection with Xanthomonas translucens. The antibiotic is readily taken up by the roots and translocated in wheat seedlings.[16] Protection in plants against several phytopathogenic fungi, e.g., B. cinerea infection of lettuce when grown in water culture containing 10 μg antibiotic per ml [9] .

MODE OF ACTION Griseofulvin prevented penetration of cell membranes by B. tulipae in tulip stems, and rendered onion epithelium impermeable to B. allii [18] .

154. GRISEOLUTEINS

SOURCE Streptomyces griseoluteus, n. sp [1] .

NATURE Acidic [1] .

MOLECULAR FORMULA Possibly $(C_{8.6}H_{7.6}NO_3)n$ [1] .

CRYSTAL FORM AND COLOR Griseolutein A: reddish-yellow needles[4] [1, 2] .
B: light yellow crystals [2] .

MELTING POINT (°C) Griseolutein A: 193 (d.) [1, 2] .
B: Darkens approximately 150 (d. >220) [2] .

/1/ c, 1.0127 acetone. /2/ c, 2 chloroform. /3/ c, 1 acetone. /4/ Recrystallized from ethyl acetate.

UV ABSORPTION MAXIMA Griseolutein A: 267, 368 mμ.
B: 281, 342 mμ. [2]

SOLUBILITY s. $NaHCO_3$; sl. s. ethyl acetate, alcohol; i. water, ether, benzene.

STABILITY Most stable at acid, least at alkaline pH [1] .

BIOLOGICAL ACTIVITY In vitro. Griseolutein A: Inhibits (μg/ml) Micrococcus pyogenes var. aureus, 0.2-0.8; Bacillus subtilis, 0.1-0.2; B. anthracis, 0.4; Escherichia coli, 5-6; Salmonella typhosa, 3.1-5.0; S. paratyphi, 3.1; S. typhimurium, 25; Shigella dysenteriae, 1.6-5.0; Proteus vulgaris, 0.2-0.4; Brucella melitensis, 0.2; Pseudomonas aeruginosa, 12.5. Weak activity against mycobacteria. [1, 2]

B: Inhibits (μg/ml) Micrococcus pyogenes var. aureus, B. anthracis, B. subtilis, Salmonella paratyphi, Shigella dysenteriae, Sh. paradysenteriae, 0.2-4.0; Salmonella typhosa, Escherichia coli, 5-10; Streptococcus sp, Salmonella typhimurium, Diplococcus pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, 25-50. [2, 4]

In vivo. Griseolutein B: S.c. doses of 1-2.5 mg protected mice against infection with M. pyogenes var. aureus [4] .

TOXICITY Griseolutein A: S.c. doses of 2000 mg/kg were sublethal to mice, but induced kidney damage [1, 3] .
B: LD_{50} in mice, 240 mg/kg, i.v.; 450 mg/kg, s.c.; 800 mg/kg, oral. [4]

ABSORPTION Griseolutein B: S.c. doses of 100 mg/kg, and oral doses of 50 mg/kg, in rabbits produced blood concentrations of approximately 50 μg/ml after 5 hours [4] .

155. GRISEOMYCIN
(Lomycin)

SOURCE Streptomyces griseolus [1] .

NATURE Basic [1] .

MOLECULAR FORMULA $C_{25}H_{46}NO_8Cl$ [2] .

CRYSTAL FORM AND COLOR White plates [1] .

MELTING POINT (°C) 76-80 (d.); HCl, 120 [1] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = +32^{\circ}$[1] [1] .

SOLUBILITY s. most organic solvents; sl.s. H_2O. HCl: s. water, methanol, ethanol, chloroform; sl.s. most other organic solvents. [1]

STABILITY Thermolabile; less stable at alkaline pH; stable at pH 2-9 at room temperature. [1]

OTHER REACTIONS Bitter taste; HCl precipitates from aqueous solution by picric acid, Reinecke salt, Br water, iodopotassium iodide; slightly positive Mandelin, Margin, Wasicky. [1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Corynebacterium diphtheriae, C. pseudodiphtheriae, Bacillus cereus, B. mycoides, B. subtilis, Mycobacterium lacticola, Streptococcus pyogenes, 0.2-0.5; B. mesentericus, 1.3; Neisseria sp, 5; Myco. smegmatis, 15; Myco. tuberculosis, 187. No inhibition at 1000 μg/ml of Pseudomonas aeruginosa, Escherichia coli, Serratia marcescens, Salmonella typhosa, Shigella spp, and Candida albicans. [1]

TOXICITY LD_{50} in mice, 210 mg/kg, i.p.; 1330 mg/kg, s.c.; oral doses of 2100 mg/kg tolerated. Lethal doses induced symptoms of neurotoxicity. Repeated daily s.c. doses of 110 mg/kg were non-toxic. [1]

RESISTANCE M. pyogenes var. aureus rapidly developed resistance in vitro; 400-fold increase (0.5-200 μg/ml) following 5 transfers in media containing antibiotic. This antibiotic shows very marked cross resistance with erythromycin and carbomycin. [1]

ABSORPTION AND EXCRETION In guinea pigs, 200 mg/kg, i.m., produced peak blood concentrations of 10 μg/ml in 35 minutes, dropping to 5 μg in 1 hour and 1.5 μg in 10 hours. High levels in urine and bile, and in lungs, spleen and kidneys; no detectable concentrations in the liver and brain. Following oral doses, highest blood levels were noted in 3 hours. In man, there was good absorption from the gastrointestinal tract following oral doses; antibiotic was excreted in the urine in concentrations up to 125 μg/ml. [3]

/1/ c, 1 chloroform.

156. GRISEOVIRIDIN

SOURCE Streptomyces griseoviridus, n. sp, and S. griseus [1, 3] .

NATURE Neutral compound [1] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{29}O_7N_3S$ (proposed); 485-490.[4]

CRYSTAL FORM AND COLOR Colorless crystals [1] .

MELTING POINT ($^{\circ}$C) (All corr.) 158-166; 194-200; 230-240[1].[1] 228-230[2]; 160[3].[4]

OPTICAL ACTIVITY $[\alpha]_D^{27} = -237^{\circ}$[4] [1, 4] .

UV ABSORPTION MAXIMA 221 mμ[5] [1]; 220.5 mμ [4] .

SOLUBILITY s. pyridine, lower alcohols; sl.s. water, non-polar solvents.[1]

STABILITY Stable at pH 2-9 for 24 hours at room temperature[6] [1] .

OTHER REACTIONS Positive Baeyer; negative $FeCl_3$, Folin-Ciocalteu, Sakaguchi, Jacobs-Hoffman. Infrared absolute maxima depend on crystal form. Analysis: C, 55.2; H, 6.2; O, 23.0; N, 8.6; S, 6.4.[1] Crystallizes from methanol in 2 forms: A is obtained above 30° and B below; form B loses solvent in air, yielding A. In water, antibiotic gives a light blue color in 1½-2 hours in the chromate-nitric acid test for primary and secondary alcohol groups.[4]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli [2] .

BIOLOGICAL ACTIVITY Active against Gram-positive and Gram-negative bacteria; no activity against fungi and protozoa. In vitro. Inhibits (μg/ml) Actinomyces bovis, Clostridium hemolyticum, Corynebacterium diphtheriae, Hemophilus pertussis. Moraxella bovis, Neisseria gonorrhoeae, 0.1-0.5; N. meningitidis, 0.5->10; N. catarrhalis, 0.25-1.0; Streptococcus pyogenes, 0.5-1.0; Str. agalactiae, 0.8; Streptococcus spp, 0.25->10; Micrococcus pyogenes var. aureus, 1.0->100; Brucella suis, 5-25; Br. abortus, 50-100; Diplococcus pneumoniae, Erysipelothrix rhusiopathiae, 10->10; Hemophilus influenzae, 1; Mycobacterium tuberculosis, 25-300; Vibrio comma, 25; Salmonella typhosa, 50->100, Shigella paradysenteriae, 2.5-10. The following were not sensitive to 10 μg/ml: Bacillus anthracis, Br. bronchiseptica, Escherichia coli, Klebsiella pneumoniae, Listeria monocytogenes, Malleomyces mallei, Paracolobactrum spp, Pseudomonas aeruginosa, Proteus vulgaris, Salmonella schottmuelleri, Clostridium perfringens, Cl. novyi, Str. salivarius, Leptospira icterohemorrhagiae, and Nocardia asteroides. Fungi are not susceptible at 200 μg/ml. Entamoeba histolytica, Trichomonas foetus, and trypanosomes were not sensitive to 250-500 μg/ml. [1]

In vivo. Daily i.p. doses of 250 mg/kg protected mice infected with H. pertussis; oral doses of 250-500 mg/kg were less effective. Some protection afforded in mouse infections with meningopneumonitis and psittacosis viruses. Activity against Rickettsia prowazeki in chick embryo. No activity against Myco. tuberculosis and Schistosoma mansoni in mice; inactive against smaller viruses.[1]

VETERINARY In limited trials in chronic bovine mastitis caused by M. pyogenes or E. coli, single infusions of 250 mg in ointment base to each udder quarter effectively eliminated these organisms. Preliminary trials indicated chickens with infectious sinusitis rendered asymptomatic following single oral dose of 250 mg.[1]

TOXICITY LD_{50} in mice, 75 mg/kg, i.v.; >100 mg/kg, i.p. or s.c. Mice tolerated 100 mg/kg, i.p. or s.c., twice daily for 10 days without evidence of toxicity. Dogs tolerated oral doses of 100-200 mg/kg/da for 10 days. Instillation of 250-1000 mg in ointment into bovine teat canal was well tolerated; no irritation when instilled into the conjunctival sac of dogs.[1]

157. HELENINE

May be identical with antibiotic 8450 of Powell and Culbertson. [3-5]

SOURCE Penicillium funiculosum [1] .

STABILITY Stable when frozen; thermolabile.[2]

OTHER REACTIONS Precipitable from 50% acetone; filterable through a Seitz pad but non-dialyzable; large amounts of polysaccharide found with crude active preparations.[1, 2]

BIOLOGICAL ACTIVITY In vivo. Good protection in mice infected with Columbia SK encephalomyelitis and Semliki Forest viruses following i.p. doses of approximately 5 mg, b.i.d.[1, 2] . Increased survival rates of mice infected with western equine encephalomyelitis virus [6] . Daily i.p. doses of 5 ml per kg for 4 days protected monkeys

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/1/ Depending on crystal modification. /2/ From pyridine. /3/ From methanol. /4/ c, 0.5 methanol.
/5/ In methanol. /6/ In culture filtrate.

157. HELENINE (Concluded)

infected orally with Mahoney strain of type I poliomyelitis virus and reduced amount of virus recoverable in feces. No protection when antibiotic was administered orally. [7]

158. HELIXIN

SOURCE Streptomyces sp [1] .

SOLUBILITY s. ethanol, methanol, methyl cellosolve, pyridine, 0.01 M phosphate buffer at pH 8.5, glacial acetic acid, n-butanol, acetone; sl.s. chloroform; i. ether, petroleum ether, benzene, ethyl acetate, carbon tetrachloride.[1]

STABILITY Thermolabile at pH 3; more stable at alkaline pH.[1]

OTHER REACTIONS Negative Molisch, ninhydrin, Hopkins-Cole, xanthoproteic, Millon, $FeCl_3$; deep red in ethanol solution; amorphous precipitate in aqueous solution below pH 4-5; components A, B, C, D present; B is identical with a component of endomycin.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Glomerella cingulata [1] .

BIOLOGICAL ACTIVITY Active against fungi and certain bacteria. In vitro. Inhibits Candida albicans, Saccharomyces cerevisiae, Trichophyton mentagrophytes; also Bacillus subtilis and Micrococcus pyogenes var. aureus at 22.5 μg/ml or less. Phytopathogenic fungi: Alternaria solani, Botrytis allii, Colletotrichum sp, Helminthosporium sp, and Verticillium sp inhibited at 7.5 μg/ml or less. [1, 2]

PHYTOPATHOLOGY Sprays (45 μg/ml solution) protected tomato leaves against Alternaria solani [3] . Was effective in control of certain Helminthosporium diseases of oats and barley and 3 covered smuts of small grain [4] . Failed to control stem rust of wheat when used as pre-inoculation spray under greenhouse conditions [5] .

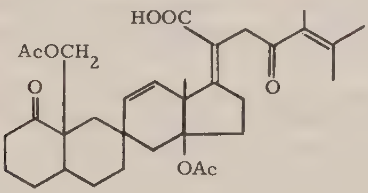
159. HELVOLIC ACID
(Fumigacin)

SOURCE Aspergillus fumigatus [1, 2] .

NATURE Monobasic acid [7] .

MOLECULAR FORMULA AND WEIGHT $C_{32}H_{42}O_8$; 555 (calc.); 585 (found for methyl ester).[13]

STRUCTURE



[12]

CRYSTAL FORM AND COLOR Fine, long, white needles [1-3, 6, 13] .

MELTING POINT (°C) 220-226 [4] ; 211.3-212.1 (d.).[13]

OPTICAL ACTIVITY $[\alpha]_D^{23} = -113^\circ$[1], -117°[2, 3] [8] ; $[\alpha]_D^{25} = -124^\circ$[4] [13] .

UV ABSORPTION MAXIMA 230, 234 mμ [5, 6] ; 231, 322 mμ [13] . Methyl helvolate: 218, 232 mμ [11] .

SOLUBILITY s. chloroform, acetone, ethyl acetate, benzene, pyridine, glacial acetic acid, dioxane, ether, warm ethanol; sl. s. cold ethanol and methanol, petroleum ether, water.[1]

STABILITY Thermostable at acid pH; unstable at alkaline.[1]

OTHER REACTIONS Yellow precipitate with $FeCl_3$; strong red color in Liebermann-Burchard; orange color in Zimmerman; yellow color with tetranitromethane; positive bile acid; negative Fehling, ammoniacal $AgNO_3$, fuchsin, sulfurous acid, Tollens, Molisch, Rosenheim, cholic acid, Jaffé-Tortelli; digitonin fails to consume periodate; fumigacin is helvolic acid plus gliotoxin.[1, 6, 8, 11-13]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1, 3, 4, 6] .

/1/ c, 3.1 chloroform. /2/ c, 2.6 chloroform. /3/ Higher rotations obtained by early investigators may have been caused by contamination with gliotoxin. /4/ c, 1 chloroform.

159. HELVOLIC ACID (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibited (in dilution x 1000) M. pyogenes var. aureus, 1280; Streptococcus pyogenes, 160-640; Corynebacterium diphtheriae, 640; Diplococcus pneumoniae, Str. viridans, 160; Bacillus anthracis, Clostridium perfringens, Cl. novyi, 320; Salmonella enteritidis, Cl. septicum, Neisseria meningitidis, 25-80; S. typhosa, Proteus sp, Pseudomonas aeruginosa, Escherichia coli, 0.5; Mycobacterium tuberculosis, 20. [1, 2] Phytopathogens (in dilution x 1000): Corynebacterium sepedonicum, 160; C. michiganense, Bacterium stewartii, Pseudomonas glycinea, 30; Agrobacterium tumefaciens, >90; Ps. syringae, Xanthomonas campestris, 40; X. pruni, 60; Ps. marginalis, X. malvacearum, 20. No activity against phytopathogenic fungi.[9, 10]

TOXICITY Mice tolerated doses of 250 mg/kg, i.v. or s.c.; oral doses of 1000 mg/kg.[1] LD$_{50}$, 400 mg/kg by i.p. route [11] . Repeated i.v. or s.c. doses of 100 mg/kg produced fatty changes in liver [1] .

RESISTANCE M. pyogenes and Str. pyogenes showed 250-fold increase in resistance after 26 transplants in antibiotic-containing media [1] . In vivo. Slight activity in mice infected with M. pyogenes and Str. pyogenes [1, 6] .

ABSORPTION Serum levels obtained after s.c., i.m., and oral doses in mice; no detectable concentration in cerebrospinal fluid.[1]

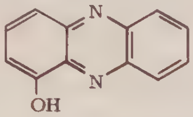
160. HEMIPYOCYANINE
(α-Hydroxyphenazine)

SOURCE Pseudomonas aeruginosa [2, 3] .

NATURE A pigment [1] .

MOLECULAR FORMULA $C_{12}H_8ON_2$ [1] .

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Yellow needles [1] .

MELTING POINT (°C) 158 [1] .

SOLUBILITY s. alkali [1] .

OTHER REACTIONS Red-violet in alkaline solution, yellow when neutralized [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (in dilutions of 1:10,000-1:1,000,000) Bacillus anthracis, Brucella abortus, Clostridium perfringens, Cl. feseri, Cl. tetani, Cl. septicum, Corynebacterium pyogenes, Escherichia coli, Micrococcus pyogenes var. aureus, Pasteurella multocida, Salmonella choleraesuis, Streptococcus agalactiae, Str. dysgalactiae, Vibrio comma, V. foetus [2, 4] . Fungi: Candida albicans and Trichophyton schoenleinii inhibited by 1:100,000, Microsporum gypseum and Trichophyton mentagrophytes by 1:20,000-1:60,000.[5]

In vivo. Some protection against Br. abortus infection in guinea pigs. Infusions of 0.5-1.0 g failed to eliminate Br. abortus from bovine udder.[4]

CLINICAL Limited value when topically used in dermatophytosis [6] .

TOXICITY I.p. doses of 500 mg/kg sublethal to mice. [2]

161. HERQUEIN

SOURCE Penicillium herquei [1] .

MOLECULAR FORMULA $C_{19}H_{20}O_8$ (proposed) [1] .

FORM AND COLOR Yellow-brown crystals [1] .

MELTING POINT (°C) 129 (d.) [1] .

SOLUBILITY s. ethanol, chloroform, ether, carbon tetrachloride; sl.s. water, benzene; i. petroleum ether.[1]

OTHER REACTIONS Precipitated by lead acetate; yellow solution in water which exhibits a bottle-green fluorescence on addition of alkali.[1]

161. HERQUEIN (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus and Vibrio comma in dilution of 1:2500. Pseudomonas aeruginosa, Shigella dysenteriae, Streptococcus pyogenes, and Mycobacterium phlei also sensitive.[1]

162. HIRSUTIC ACIDS

SOURCE Stereum hirsutum [1] .

NATURE Several active and inactive acids [1] .

MOLECULAR FORMULA AND WEIGHT Hirsutic acid C: $C_{15}H_{20}O_4$ (proposed); 260-264 (titr.); 264 (calc.).[1]

CRYSTAL FORM AND COLOR Hirsutic acid C: large, colorless prisms.
N: transparent, colorless, non-crystalline solid.[1]

MELTING POINT (°C) Hirsutic acid C: 179.5 (uncorr.) [1] .

OPTICAL ACTIVITY $[\alpha]_{D}^{20} = +11.9^{\circ}$[1] [1] .

UV ABSORPTION MAXIMA Hirsutic acid C: No UV spectrum [1] .

SOLUBILITY Hirsutic acid C: s. most organic solvents; sl. s. water; i. hexane, CCl_4.
N: s. alkali and most organic solvents; sl.s. hot water; i. cold water, hexane, CCl_4.[1]

STABILITY Hirsutic acid N: Stable as free acid solid; less stable in water, especially at alkaline pH.[1]

OTHER REACTIONS Group of active and inactive acids of which C is an inactive precursor, while A, N and some other derivatives are active; negative Fehling, ammoniacal $AgNO_3$, 2,4-dinitrophenylhydrazine, acidified KI; decolorized $KMnO_4$; white precipitate with Br water; faint brown color with $FeCl_3$; C titrates as a monobasic acid, pKa 4.6.[1]

QUANTITATIVE DETERMINATION: Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Hirsutic acid A: Inhibits M. pyogenes var. aureus at 1:8000; Streptococcus pyogenes less sensitive; no activity against Salmonella enteritidis and Escherichia coli.[1]
N: Inhibits Corynebacterium diphtheriae and Neisseria meningitidis in dilution of 1:40,000; M. pyogenes var. aureus and Str. pyogenes at 1:10,000. M. lysodeikticus, Sarcina lutea, Bacillus anthracis, B. subtilis, and Vibrio comma less sensitive; no activity against S. enteritidis and E. coli.

TOXICITY Hirsutic acid A: LD_{100}, 15-20 mg, i.v.
C: Atoxic to mice in high doses.[1]
N: LD_{100} in mice, 1-2 mg, i.v.; oral doses of 20 mg tolerated.
A, N: In vitro, both are toxic to leukocytes in dilution of 1:16,000.

163. HOMOMYCIN

SOURCE Streptomyces noboritoensis, n. sp [1] .

FORM AND COLOR White powder [1] .

MELTING POINT (°C) 105-109[2] [1] .

UV ABSORPTION MAXIMA 270-272 mμ [1] .

SOLUBILITY s. water, lower alcohols; sl. s. other organic solvents.[1]

OTHER REACTIONS Some resemblance to hygromycin; positive diazo, Nessler, Fehling, Tollens, indole, carbazole; negative ninhydrin, $FeCl_3$, biuret. Analysis: C, 53.60; H, 6.85; N, 2.70.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis var. hominis and Myco. tuberculosis var. bovis at 5; Micrococcus flavus, M. pyogenes var. aureus, 25; Bacillus agri, 100; Myco. phlei, 250; B. subtilis, Escherichia coli, 500. A streptomycin-resistant strain of E. coli was sensitive to 50 μg/ml of homomycin.[1]

TOXICITY Mice tolerated i.v. doses of >2000 mg/kg [1] .

/1/ Free acid in absolute alcohol. /2/ Decomposes gradually above 160°C.

164. HUMICOLIN

SOURCE Aspergillus humicola [2] .

NATURE Weakly acidic [2] .

FORM AND COLOR Yellow oil [1, 2] .

SOLUBILITY s. most organic solvents; sl. s. water; i. petroleum ether. [1]

STABILITY Relatively stable at pH 3.5-4.5, unstable above. [1, 2]

OTHER REACTIONS Brown color with $FeCl_3$ in alcoholic solution; inactivated by UV in sodium bicarbonate solution.[2]

QUANTITATIVE DETERMINATION Microbiological: Botrytis allii spore germination [1, 2] .

BIOLOGICAL ACTIVITY In vitro: Inhibits fungi (μg/ml): Aspergillus niger, A. terreus, Fusarium caeruleum, Mucor mucedo, Myrothecium verrucaria, Penicillium expansum, 0.8-6.2; B. allii, 1; Trichoderma viride, 12.5-25.0.[2]

165. HYDROXYSTREPTOMYCIN

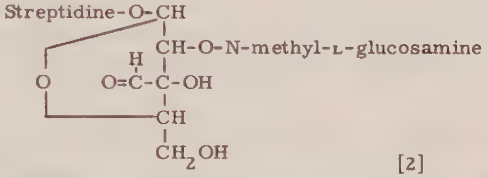
Identical with reticulin of Hosoya, et al.[5]

SOURCE Streptomyces griseo-carneus, n. sp [1] .

NATURE Basic [1] .

MOLECULAR FORMULA $C_{21}H_{39}N_7O_{13}$ [1, 2] .

STRUCTURE



[2]

CRYSTAL COLOR Helianthate: reddish-brown crystals. Trihydrochloride: white.[2]

MELTING POINT (°C) Helianthate: Darkens at 220; chars without melting.[2]

OPTICAL ACTIVITY Trihydrochloride: $[\alpha]^{28}_{D} = -91^{\circ}$[1] [2] .

OTHER REACTIONS X-ray diffraction pattern like that of streptomycin; more stable to acid hydrolysis than is streptomycin.

% Activity Remaining (in 2N HCl at 20°C)

	1 day	2 days	7 days	21 days
Streptomycin	50	19	<1	
Hydroxystreptomycin	93	85	58	20

[2, 3]

BIOLOGICAL ACTIVITY Antimicrobial spectrum same as that of streptomycin (q.v.) [1, 4] .

TOXICITY About the same as streptomycin and dihydrostreptomycin. Marked ototoxicity in cats. LD_{50} in mice, 865 mg/kg, s.c. [4] ; LD_0, 550 mg/kg, i.v.; 440 mg/kg, i.p.[5]

166. HYGROMYCIN

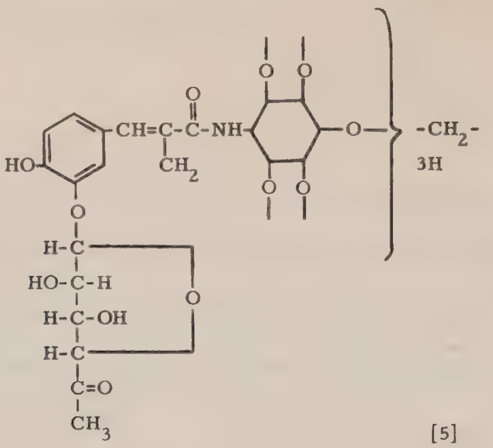
SOURCE Streptomyces hygroscopicus (Jensen) [1] .

NATURE Weakly acidic [2] .

MOLECULAR FORMULA AND WEIGHT $C_{23}H_{29}NO_{12}$ [5] ; 536 ± 25 (titr.).[2]

/1/ c, 1 water.

STRUCTURE



[5]

CRYSTAL FORM Not crystallized [2] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -126^{\circ}$[1] [2] .

UV ABSORPTION MAXIMA 272, 214[2] [2, 5] ; 254, 286, 323 mμ[3] [5] .

SOLUBILITY s. water, alcohol; i. less polar solvents.[2]

STABILITY Thermostable at pH 3 to 7; unstable above 9.[1]

OTHER REACTIONS Not greatly affected by pH of assay medium; positive Folin-Ciocalteu, Benedict, Fehling; negative $FeCl_3$, anthrone, Molisch, maltol. Infrared: Strong absorption bands at 3.0, 5.84, 6.08, 6.22, and 6.62 μ.[2, 5]

QUANTITATIVE DETERMINATION Microbiological: Klebsiella pneumoniae [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus sphaeroides, Hemophilus ducreyi, 0.2; Mycobacterium tuberculosis, 1-2; Lactobacillus lactis, 1.6; Bacillus brevis, B. polymyxa, Streptococcus pyogenes, Str. mitis, 3.1; Corynebacterium diphtheriae, Sarcina lutea, Shigella paradysenteriae, 6.2; Aerobacter aerogenes, K. pneumoniae, Proteus vulgaris, Micrococcus flavus, M. lysodeikticus, 12.5; M. pyogenes var. aureus, 12.5-50; Lactobacillus spp, Leuconostoc citrovorum, Str. faecalis, Str. lactis, Str. salivarius, Streptococcus spp, 25->25; Salmonella ambigua, S. enteritidis, Myco. avium, Myco. phlei, 50. B. cereus, B. macerans, B. subtilis, Brucella bronchiseptica, Escherichia coli, Neisseria catarrhalis, Pseudomonas aeruginosa, S. gallinarum, S. paratyphi, 100 μg/ml or greater. Actinomycetes (μg/ml): Nocardia coeliaca, 12.5; Streptomyces lavendulae, 6.2; N. gardneri, S. diastaticus, S. griseus, 50; S. venezuelae, 100. Fungi: Trichophyton rubrum, Candida albicans, Saccharomyces pastorianus, 100 μg/ml or greater.[1, 3, 4]

In vivo. Good protection in mice infected with Myco. tuberculosis, Str. pyogenes, and Borrelia novyi; moderate activity against K. pneumoniae.[1, 3] Activity demonstrated in mice infected with meningopneumonitis virus; no effect on smaller viruses, e.g., poliomyelitis "MM" and Semliki Forest viruses.[1, 3]

TOXICITY I.v. doses of 1000 mg/kg tolerated in mice.

RESISTANCE K. pneumoniae acquired 1600-fold resistance following six transfers in antibiotic-containing media; strains of Str. pyogenes, M. pyogenes var. aureus and Mycobacterium sp did not readily develop resistance in vitro. Bacteria, made resistant to hygromycin, showed increased resistance to chlortetracycline, oxytetracycline, and, in some instances, erythromycin.[3]

MODE OF ACTION Although relatively high concentrations are required for bacteriostasis in vitro, the same or lower levels show marked bactericidal effect. Activity depressed by cysteine, thiamine, biotin and ascorbic acid in vitro.[3]

167. HYGROSCOPINS

SOURCE Streptomyces hygroscopicus [11] .

NATURE Oils [2] .

/1/ c, 1 water. /2/ Dilute HCl. /3/ Dilute alkali.

167. HYGROSCOPINS (Concluded)

MOLECULAR FORMULA AND WEIGHT Hygroscopin A: $C_{13}H_{24}O_3N_2$.
B: $C_{15}H_{28}O_3N_2$.[2]

OPTICAL ACTIVITY Hygroscopin A: $[\alpha]_D^{14} = +84.7^{\circ 1}$.
B: $[\alpha]_D^{14} = -38.8^{\circ 1}$.[2]

UV ABSORPTION MAXIMA Hygroscopin A: 235 $m\mu^2$.
B: 233 $m\mu^2$.[2]

OTHER REACTIONS Three fractions from carbon chromatography and distillation.

Hygroscopin A: refractive index $n_D^{13} = 1.4830$, BP 0.003 64°.
B: refractive index $n_D^{14} = 1.4935$, BP 0.008 70°. [2]

BIOLOGICAL ACTIVITY In vitro. Active against phytopathogenic fungi [1] .
Hygroscopin A: Inhibits Mycobacterium tuberculosis var. hominis at 10 μg/ml. Influenza virus inhibited in tissue cultures by concentration of 10 μg/ml.
B: Inactive against Myco. tuberculosis. Influenza virus inhibited by 10 μg/ml tissue culture.[2]
In vivo. Hygroscopin A, B: Doses of 1 mg/kg retarded development of Yoshida sarcoma in animals [2] .

ACUTE TOXICITY Hygroscopin A: LD_{50} in mice, 8.8 mg/kg, i.p.
B: LD_{50} in mice, 19.3 mg/kg, i.p.[2]

168. ILLUDINS

SOURCE Clitocybe illudens [1] .

NATURE Neutral [1] .

MOLECULAR FORMULA AND WEIGHT Illudin M: $C_{15}H_{20}O_3$; 241 (found); 248 (calc.).[1]
S: $C_{15}H_{22}O_4$; 264 (found); 266 (calc.).[1]

MELTING POINT (°C) Illudin M: 130-131 (uncorr.).
S: 124-125 (uncorr.).[1]

OPTICAL ACTIVITY Illudin M: $[\alpha]_D^{20} = -126^{\circ 3}$.
S: $[\alpha]_D^{20} = -165^{\circ 3}$.[1]

UV ABSORPTION MAXIMA Illudin M: 230, 320 $m\mu^2$.
S: 255, 328 $m\mu^2$.[1]

SOLUBILITY s. organic solvents; less s. water.[1]

STABILITY Relatively stable [1] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Mycobacterium smegmatis [1] .

BIOLOGICAL ACTIVITY In vitro. Illudin M: Inhibits (μg/ml) Myco. tuberculosis, Myco. smegmatis, Myco. ranae, 1; Klebsiella pneumoniae, 16; Bacillus subtilis, 500. Weak antifungal activity.
S: Inhibits (μg/ml) Myco. tuberculosis, 6; Myco. ranae, 5; Myco. smegmatis, K. pneumoniae, M. pyogenes var. aureus, 4; B. subtilis, 31. No antifungal activity.[1, 2]
In vivo. Daily i.p. doses of 0.8 mg/kg of illudin M for 7 days had no inhibitory effect on RC carcinoma in mice [5] . Illudin M and S active in chicks infected with Plasmodium gallinaceum, but active dosages (2-5 mg/kg/da) were fairly toxic [3] . Slight retardation of growth of Crocker sarcoma 180 following i.p. administration of 0.6-0.8 mg/kg/da in mice [4] .

RESISTANCE Strains of B. megatherium and Myco. ranae showed complete cross resistance in vitro between illudin M and S [6] .

169. INOLOMIN

SOURCE Inoloma traganum [1] .

FORM AND COLOR Yellow, glassy, hygroscopic, amorphous [1] .

SOLUBILITY s. water, pH 7 phosphate buffer [1] .

/1/ Methanol. /2/ Ethanol. /3/ Absolute ethanol.

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169. INOLOMIN (Concluded)

STABILITY Thermolabile; stable at room temperature [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus sp and Corynebacterium pseudodiphtheriticum [1] .

TOXICITY Mice tolerated i.v. doses of 5000 mg/kg [1] .

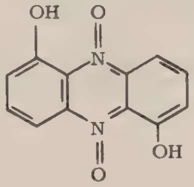
170. IODININ

SOURCE Chromobacterium iodinum [1] .

NATURE Bacterial pigment [1] .

MOLECULAR FORMULA $C_{12}H_8O_4N_2$ [1] .

STRUCTURE



[4]

CRYSTAL FORM AND COLOR Purple crystals with a coppery glint [1] .

MELTING POINT (°C) 236 (d.) [1] .

SOLUBILITY s. benzene, toluene, xylene, chloroform, carbon disulfide, ethyl acetate; sl. s. hot alcohol; i. ether, cold alcohol, acetic acid, petroleum ether, amyl alcohol [4] .

STABILITY Acid stable, alkali unstable [1] .

OTHER REACTIONS pK about 12.5; blue-green, water-soluble salt with alkali; decomposed by heat to a gray colloidal substance, reformed by acidification and addition of benzene; activity antagonized by anthraquinone and naphthaquinone derivatives.[1-4]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli, Streptococcus pyogenes [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Str. pyogenes, 0.4-2.0; Micrococcus pyogenes var. aureus, 8-43.[1, 2]

171. ISORHODOMYCINS

SOURCE Streptomyces purpurascens [1] .

MOLECULAR FORMULA AND WEIGHT Isorhodomycin A HCl: $C_{20}H_{29}O_8N$. HCl; 447.9 (calc.); or $C_{21}H_{31}O_8N$. HCl: 461.9 (calc.).[1]

CRYSTAL FORM AND COLOR Isorhodomycin A HCl: dark red prisms [1] .
A perchlorate: thin, red needles [1] .

MELTING POINT (°C) Isorhodomycin A HCl: 220 [1] .
A perchlorate: 177 [1] .

OPTICAL ACTIVITY Isorhodomycin A HCl: $[\alpha]^{18}_{606-760} = +268^{\circ} \pm 30$ [1] [1] .

ABSORPTION MAXIMA: Isorhodomycin A HCl: 610, 563, 551 mμ [2] [1] .

SOLUBILITY Isorhodomycin A HCl: s. water, lower alcohols; sl. s. benzene, chloroform; i. ether, petroleum ether.[1]

OTHER REACTIONS Compound B recognized by paper chromatography; isorhodomycin A HCl crimson red in solution; intense red fluorescence under UV lamp; occurs with rhodomycin A, both on mild hydrolysis giving a water-insoluble N-free chromophore, and a water-soluble N-containing fraction.[1]

/1/ c, 0.1 methanol. /2/ Methanol.

171. ISORHODOMYCINS (Concluded)

BIOLOGICAL ACTIVITY In vitro. Isorhodomycin A: Inhibits Micrococcus pyogenes var. aureus in dilution of 1:30,000,000.[1]

172. ITURINS

SOURCE Bacillus subtilis [1] .

NATURE Iturin L: protein [2] .

CRYSTAL FORM AND COLOR Iturin L: gray powder.
N: yellow powder.
O: brown substance.[1]

UV ABSORPTION MAXIMA Iturin L: 278 mμ.
N: 270 mμ.
O: 260 mμ.

SOLUBILITY Iturin L: s. water, methanol, ethanol, propanol, pyridine; i. amyl acetate, ether, carbon disulfide, cyclohexanol, dioxane, petroleum ether, acetone.[2]
N: i. benzene.
O: s. benzene.[1]

STABILITY Stable at 100°C, but loss on autoclaving [1] .

OTHER REACTIONS Iturin L: Non-dialyzable; stable in UV after 30 minutes; precipitates with many agents; positive biuret, xanthoproteic, Millon; negative Liebermann; Raspail, Sakaguchi, Adamkiewicz; not inactivated by trypsin, pepsin, papain, H_2S; inactivated by H_2O_2, HCHO; contains several amino acids.
Iturin N: Dialyzable; inactivated by UV in 10 minutes.
O: Dialyzable; stable in UV 20-25 minutes.[2]

QUANTITATIVE DETERMINATION Microbiological: Iturin L: Penicillium notatum [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibit Sarcina lutea, Bacillus subtilis, B. megatherium, Micrococcus pyogenes var. aureus, and P. notatum [1] .

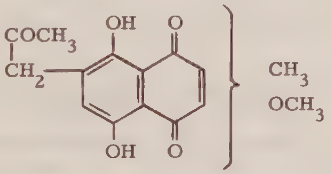
173. JAVANICIN

SOURCE Fusarium javanicum [1] .

NATURE Weak monobasic acid [1] .

MOLECULAR FORMULA $C_{15}H_{14}O_6$ [1, 3] .

STRUCTURE



[2, 3]

CRYSTAL FORM AND COLOR Red laths with coppery luster [1, 3] .

MELTING POINT (°C) 207.5-208 (d.) [1, 3] .

OPTICAL ACTIVITY Inactive [1] .

ABSORPTION MAXIMA 303, 505 mμ[1] [1] .

SOLUBILITY s. water, organic solvents; sl. s. petroleum ether.[1]

STABILITY Thermo-, acid, and alkali stable [1, 3] .

OTHER REACTIONS Deep violet color with 10% NaOH, purple with ammonia or sodium carbonate, violet with lead acetate in methanol; no color with sodium bicarbonate; decolorized by Br water or aqueous sodium bisulfite; active derivatives; oxyjavanicin ($C_{15}H_{14}O_7$, MP 212°C) also occurs in culture filtrates.[1, 3]

/1/ Ethanol.

173. JAVANICIN (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, Streptococcus pyogenes, Clostridium perfringens, Mycobacterium tuberculosis, Myco. phlei, Bacillus subtilis in dilution of 1,40,000-1:200,000. Pseudomonas aeruginosa, Escherichia coli not sensitive to 1:10,000.[2]

In vivo. No activity in guinea pigs infected with Myco. tuberculosis [2] .

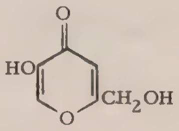
TOXICITY Mice tolerated i.p. doses of 500 mg/kg [2] .

174. KOJIC ACID

SOURCE Aspergillus spp[1], Penicillium daleae, Acetobacter spp [1, 4, 10] .

MOLECULAR FORMULA $C_6H_6O_4$ [1] ; 142 (cryo., calc.) [10] .

STRUCTURE



[11]

CRYSTAL FORM AND COLOR Colorless prisms [3, 10] .

MELTING POINT (°C) 158 [3] ; 151-154 [10] .

OPTICAL ACTIVITY Inactive [3] .

SOLUBILITY s. water, alcohol, acetone; sl. s. ether, chloroform, pyridine, ethyl acetate; i. benzene.[3, 10]

STABILITY Thermostable at pH 3-7.5 [3] .

OTHER REACTIONS Red color with $FeCl_3$; reduces Fehling; slowly inactivated by dilute alkali; reacts nearly quantitatively with KCN.[3, 9]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Escherichia coli [2] . Colorimetric with $FeCl_3$. Isolation of Cu salt.[3]

BIOLOGICAL ACTIVITY In vitro. Low activity against a variety of Gram-positive and Gram-negative bacteria. Inhibits Pseudomonas aeruginosa, 1:3200-1:6400; M. pyogenes var. aureus, E. coli, Proteus spp, Salmonella typhosa, S. enteritidis and other bacteria at 1:800-1:4000.[2, 3] Microorganisms responsible for spoilage of Japanese saké inhibited by 2-4 mg/ml [5] . Leptospira canicola inhibited by 1:1,000,000; L. icterohemorrhagiae, 1:100,000.[3]

In vivo. No activity against viruses of poliomyelitis and St. Louis encephalitis in mice [6] . No protection in chicks infected with Plasmodium gallinaceum [7] .

CLINICAL Topical use in wounds infected with Pseudomonas aeruginosa gave indifferent results [4] .

TOXICITY Doses of 250 mg/kg, administered s.c., i.p., or i.v., produced toxic symptoms in mice; 1500 mg/kg lethal. Oral doses of 1000 mg/kg were tolerated and 2000 mg/kg were toxic.[2, 3] I.v. doses of 1000 mg/kg were lethal to rabbits, rats, and dogs; 150 mg/kg, i.v., toxic to dogs.[8]

In vitro. 1:400 dilution non-toxic to leukocytes; 1:100 was lethal.[2]

175. LACTAROVIOLIN

SOURCE Lactarius deliciosus [1] .

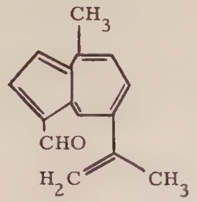
NATURE Violet-red pigment; an azulenealdehyde.[1-3]

MOLECULAR FORMULA $C_{15}H_{14}O$ [1] .

/1/ Especially strains of the A. tamaris-oryzae group.

175. LACTAROVIOLIN (Concluded)

STRUCTURE



[2, 3]

MELTING POINT (°C) 53 [1] .

ABSORPTION MAXIMA Cyclohexane: 541, 390, 311, 241 mμ. Alcohol: 527, 398, 315, 242 mμ. Formic acid: 455, 407, 331, 286 mμ. 50% H_2SO_4: 430, 391, 323, 270, 237, 228 mμ.[3]

SOLUBILITY s. organic solvents; i. water [1] .

OTHER REACTIONS Reacts with carbonyl reagents [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibited a strain of Mycobacterium tuberculosis var. hominis in dilution of 1:16,000. The azulylacrylic acid derivative showed similar activity.[1]

176. LATERITIIN GROUP

SOURCE Fusarium spp [1] .

NATURE Neutral compounds [3] .

MOLECULAR FORMULA AND WEIGHT Lateritiin I: $C_{26}H_{46}O_7N_2$; 523 (cryo.); 498 (calc.).
Lacteritiin II: $C_{26}H_{46}O_7N_2$.
Avenacein: $C_{25}H_{44}O_7N_2$; 489-494 (cryo.); 484 (calc.).
Fructigenin: $C_{26}H_{44-46}O_7N_2$.
Sambucinin: $C_{24}H_{42}O_7N_2$.[3]

CRYSTAL FORM AND COLOR Colorless plates or tetrahedra [3] .

MELTING POINT (°C) Lateritiin I: 121-122.
Lateritiin II: 125.
Avenacein: 139.
Fructigenin: 129.
Sambucinin: 86-87.[3]

OPTICAL ACTIVITY Lateritiin I: $[\alpha]^{20}_{D} = -95.6^{\circ} \pm 2.0$[1].
Lateritiin II: $[\alpha]^{19}_{D} = -92.0^{\circ} \pm 1.6$[2].
Avenacein: $[\alpha]^{19}_{D} = -101^{\circ} \pm 2.0$[1].
Fructigenin: $[\alpha]^{18}_{D} = -103^{\circ} \pm 2.0$[1].
Sambucinin: $[\alpha]^{21}_{D} = -83.2^{\circ} \pm 2.0$[1].[3]

UV ABSORPTION Absorption only below 219 mμ [3] .

SOLUBILITY s. organic solvents; sl. s. water. [3]

STABILITY Thermo- and acid stable; alkali unstable.[3]

OTHER REACTIONS HCl or HBr degradation yields nitrogen base and α-hydroxyisovaleric acid; lateritiin I and enniatin A probably identical.[2, 3]

BIOLOGICAL ACTIVITY In vitro (inhibition dilution x 1000). Lateritiin I: Mycobacterium phlei, 200-320; Micrococcus pyogenes var. aureus, 50; Streptococcus pyogenes, 40; Bacillus subtilis, 80. (See enniatin A.) [1]
Lateritiin II: Myco. phlei, 160-320; M. pyogenes var. aureus, 40; Str. pyogenes, 25; B. subtilis, 30.
Avenacein: Myco. phlei, 160; M. pyogenes var. aureus, Str. pyogenes, 10; B. subtilis, 5.
Fructigenin: Myco. phlei, 200-300; M. pyogenes var. aureus, 20; Str. pyogenes, 50; B. subtilis, 10.
Sambucinin: Myco. phlei, 40-200; M. pyogenes var. aureus, 40; Str. pyogenes, 20; B. subtilis, 10.

/1/ c, 1 ethanol. /2/ c, 1.2 ethanol.

176. LATERITIIN GROUP (Concluded)

TOXICITY Low i.p. toxicity in mice [1] .

177. LATEROSPORINS

SOURCE Bacillus laterosporus [1] .

NATURE Peptides [1] .

SOLUBILITY s. acid water; i. ether, chloroform, amyl acetate.
Laterosporin A: s. absolute ethanol.
B: i. absolute ethanol.[1]

STABILITY Thermostable at pH 2-8 [1] .

OTHER REACTIONS Dialyze through cellophane [1] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY *In vitro*. Laterosporin A, B: Inhibit (µg/ml) M. pyogenes var. aureus, 0.01; Streptococcus pyogenes, 0.03-0.12; Corynebacterium xerose, 0.003-0.005; C. diphtheriae, 0.12; Escherichia coli, 0.6; Mycobacterium phlei, 0.004-0.008; Myco. smegmatis, 10; Myco. tuberculosis, 1; Pseudomonas aeruginosa, 5-10; Salmonella enteritidis, 1.2-2.5; S. typhosa, 0.6; Clostridium botulinum, 0.02.[1, 2] In vitro activity lowered by serum [1] .

178. LAVENDULIN

SOURCE Streptomyces sp resembling S. lavendulae [1] .

NATURE Basic [2] .

MOLECULAR FORMULA Helianthate: probably $C_{49}H_{63}O_{18}N_{13}S_3$; less probable, $C_{33}H_{42}O_{12}N_8S_2$ or $C_{16}H_{20}O_6N_4S$.[2]

CRYSTAL FORM AND COLOR Helianthate: orange needles or irregular triangular blades [2] .

MELTING POINT (°C) Helianthate: 212-220 (d., corr.) [2] .

SOLUBILITY s. methanol, water; i. ether, ethanol. [2]

STABILITY Thermostable at neutral pH [2] .

OTHER REACTIONS Free base: positive biuret, Fehling, $KMnO_4$; negative Sakaguchi, Molisch; dialyzes through cellophane; NaCl reduces activity.[2]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli [1, 2] .

BIOLOGICAL ACTIVITY *In vitro*. Inhibits, in concentration of 6 µg/ml or less, Aerobacter aerogenes, Bacillus anthracis, B. subtilis, B. mesentericus, Corynebacterium diphtheriae, C. xerose, Brucella melitensis, E. coli, Mycobacterium tuberculosis, Myco. smegmatis, Micrococcus pyogenes var. aureus, Neisseria catarrhalis, Salmonella spp, S. typhosa, Shigella dysenteriae, Proteus vulgaris, Klebsiella pneumoniae, Vibrio comma. The following bacteria were not sensitive to 100 µg/ml: Diplococcus pneumoniae, Streptococcus pyogenes, Str. viridans, Pseudomonas aeruginosa.[1]

In vivo. I.p. doses of 25 µg (0.125 mg/kg) gave good protection against K. pneumoniae infection in mice [3] .

TOXICITY LD_{100} in mice, 25 mg/kg, i.p. Sublethal doses induced liver damage. [3]

179. LENZITIN

SOURCE Lenzites sepiaria (Wulf) [1] .

CRYSTAL FORM AND COLOR Thin, colorless needles [1] .

MELTING POINT (°C) 166-168 [1] .

SOLUBILITY s. chloroform, benzene, dioxane, amyl acetate, acetone; sl.s. alcohol, ether, water.[1]

STABILITY Thermolabile [1] .

179. LENZITIN (Concluded)

OTHER REACTIONS Dissolves in alkali upon heating, with partial loss of activity; violet color with $FeCl_3$; $KMnO_4$ reduced in alcoholic and aqueous solution; no halogens, N or S.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Shigella dysenteriae, Sh. paradysenteriae, Salmonella typhosa, S. paratyphi, S. schottmuelleri, Escherichia coli, Klebsiella pneumoniae, Proteus vulgaris, Corynebacterium diphtheriae, Streptococcus pyogenes, Str. viridans, Bacillus subtilis, B. mycoides, B. mesentericus. No activity against Pseudomonas aeruginosa, Ps. fluorescens, Serratia marcescens.[1]

TOXICITY Irritating to conjunctiva and mucous membranes of nasopharynx [1] .

180. LEUCOMYCIN

SOURCE Streptomyces kitasatoensis, n. sp [1] .

NATURE Basic [1, 3] .

MOLECULAR FORMULA $C_{33-38}H_{54-66}NO_{11-13}$ [3] .

MELTING POINT (°C) 124-125.5 [2] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -60.42^{\circ 1}$ [1] ; $[\alpha]_D^{20} = -67.1^{\circ 2}$ [2, 3] .

UV ABSORPTION MAXIMA 230-232, 285 $m\mu^3$ [1-3] .

SOLUBILITY Free Base: s. alcohols, acetone, ethyl acetate, butyl acetate, chloroform, ether, benzene [1, 3] ; sl.s. water [1, 4] ; i. petroleum ether, hexane [1, 3] . Tartrate: s. water [1, 4] .

STABILITY Thermostable, acid labile [1, 3] .

OTHER REACTIONS PK 7.5; resembles erythromycin and carbomycin; negative Fehling, Benedict, biuret, ninhydrin, Sakaguchi, glucosamine, xanthoproteic, $FeCl_3$, maltol; weakly positive Tollens, Seliwanoff, Molisch.[1-3] Characteristic deep violet color slowly fading to reddish brown in concentrated mineral acid [4, 5] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209-P [3] . Colorimetric [5] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, Streptococcus sp, Clostridium sp, Hemophilus pertussis, Neisseria gonorrhoeae, Klebsiella pneumoniae, and Leptospira icterohemorrhagiae at 0.04-12.5 μg/ml. Salmonella spp, Proteus spp, Pseudomonas spp, and fungi not sensitive.[1] Cl. perfringens, Cl. novyi, Cl. septicum, Cl. histolyticum, and Cl. tetani sensitive to 0.05-1.5 μg/ml [6] .

In vivo. Daily doses of 50 mg/kg gave high protection in mice against Diplococcus pneumoniae, Borrelia recurrentis, and Rickettsia tsutsugamushi, and against R. prowazeki in chick embryos [4] . Good protection against Cl. perfringens when guinea pigs were injected with 50 mg/kg immediately after infection but no protection when treatment was delayed 2 hours [6] . No protection in mice infected with rabies virus or with Trypanosoma evansi [4] .

TOXICITY LD_{50} in mice, 650 mg/kg, i.v.; >800 mg/kg, s.c.; >2000 mg/kg (tartaric salt), oral.[1]

RESISTANCE M. pyogenes var. aureus developed resistance after 14 transfers in media containing antibiotic. The strain showed cross resistance to carbomycin, but not to erythromycin.[2]

MISCELLANEOUS After darkening one cotyledon of a cucumber seedling, there is increased growth of that side of the hypocotyl; addition of leucomycin or oxytetracycline to the soil markedly increased the resulting curvature of the seedling.[7]

181. LEVOMYCIN

SOURCE Streptomyces sp [1] .

NATURE Peptide with an aromatic group [1] .

MOLECULAR FORMULA AND WEIGHT $C_{27}H_{38}N_6O_{10}$ (proposed); 550-660 (Rast); 606.6 (calc.).[1]

CRYSTAL FORM AND COLOR White or colorless prisms [1] .

MELTING POINT (°C) $213\text{-}215^4$; $218\text{-}220^5$; $222\text{-}224^6$.[1]

/1/ c, 2 ethanol. /2/ c, 1 ethanol. /3/ Ethanol. /4/ From hot isopropanol. /5/ From cold chloroform/methanol. /6/ From chromatography.

181. LEVOMYCIN (Concluded)

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = -290^{\circ}$[1], -323°[2].[1]

UV ABSORPTION MAXIMA 318, 243 mμ [1] .

SOLUBILITY s. chloroform, pyridine; less s. carbon tetrachloride, ethyl acetate, hot alcohols; sl. s. ether, benzene, cold alcohols, acetone, dioxane; i. water, petroleum ether, 5% aqueous HCl and NaOH.[1]

OTHER REACTIONS Soluble in cold 6 N HCl, but decomposes slowly; negative ninhydrin, biuret, Millon, Hopkins-Cole, Pauly, Sakaguchi, maltol, Benedict, Tollens, 2,4-dinitrophenylhydrazine, Br water, bromine (CCl_4), $KMnO_4$, periodate, methanolic $FeCl_3$, Molisch, Zn-NH_4Cl, Zeisel alkoxyl, hydroxamic acid; positive pine splint; converted to an acid (designated levomycic) when treated with cold dilute methanolic NaOH.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Listeria monocytogenes, Spirillum serpens, and Mycobacterium phlei, <1.0; Pasteurella multocida, Micrococcus pyogenes var. aureus, 5; Myco. ranae, Bacillus subtilis, 10; Myco. tuberculosis, Myco. avium, Corynebacterium diphtheriae, Klebsiella pneumoniae, 20; Escherichia coli, Salmonella gallinarum, 40-80; Streptococcus faecalis, Pseudomonas aeruginosa, >80.[1]

TOXICITY LD_{100} of crude preparations in mice, 44 mg/kg, i.v.[1]

182. LICHENIFORMINS

SOURCE Bacillus licheniformis [1] .

NATURE Peptides [2] .

MOLECULAR WEIGHT Licheniformin A: 4400 (found).
B: 3800 (found).
C: 4800 (found).[2]

FORM AND COLOR HCl: white, amorphous powder [1, 2] .

MELTING POINT (°C) No melting point; char on strong heating.[1]

OPTICAL ACTIVITY Licheniformin A HCl: $[\alpha]^{20}_{D} = -37.4^{\circ}$; $[\alpha]^{20}_{5461} = -45.2^{\circ}$.
B HCl: $[\alpha]^{20}_{D} = -37.7^{\circ}$; $[\alpha]^{20}_{5461} = -48.2^{\circ}$.
C HCl: $[\alpha]^{20}_{D} = -36.8^{\circ}$; $[\alpha]^{20}_{5461} = -44.9^{\circ}$.[2]

UV ABSORPTION Below 250 mμ[3] [1, 2] .

SOLUBILITY HCl: s. water, methanol; sl. s. ethanol; i. dry n-butanol, acetone, non-polar organic solvents.[1]

STABILITY Thermostable; unstable to concentrated acid, alkali.[1]

OTHER REACTIONS Unstable to light after long exposure; slow dialysis; positive biuret, Sakaguchi; negative ninhydrin, Molisch, glucosamine; precipitate with sodium hypochlorite.

Licheniformin A, B: Contain aspartic acid, glycine, serine, proline, arginine, phenylalanine, valine, lysine.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium phlei [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibit (in dilution x 100,000) Corynebacterium renale, 400; C. diphtheriae, 12.5-100; Myco. phlei, 25-50; Myco. tuberculosis, 1.6-6.4; Micrococcus pyogenes var. aureus, 12.5-50; Streptococcus spp, 0.8-12.5; Pasteurella multocida, 0.05-6.4; Brucella abortus, 3.2; Bacillus anthracis, 2.0; Shigella paradysenteriae, 0.4-1.6; Diplococcus pneumoniae, 0.2-1.6; Escherichia coli, 0.1-0.8; Pseudomonas aeruginosa, 0.4; Vibrio comma, Salmonella schottmuelleri, Str. viridans, 0.05-0.2; Myco. ranae, 7.5.[1, 3] Licheniformin A inhibited Myco. phlei, 50. B inhibited the same organism in 100. C, the same organism in 3.2.[2]

In vivo. Slight protection afforded in mice against infections with Str. pyogenes, B. anthracis, and Myco. tuberculosis var. bovis, after 25-450 mg/kg doses [1] .

Licheniformin A: Showed some activity in experimental mouse tuberculosis following s.c. doses of 150-300 mg/kg/da [2] .

PHARMACOLOGY LD_{50} in mice, 250 mg/kg, i.v.; 375 mg/kg, i.p.; 1000 mg/kg, s.c. Crude preparations administered s.c. daily to mice in doses of 300 mg/kg induced renal damage. Readily absorbed following s.c. injection, with maximum blood levels in 1-2 hours.[1] Product A less toxic than B or C in mice; C is the most toxic. Slight kidney damage following 14 daily s.c. doses of A; renal changes severe with same doses of B and C.[2] Injection of licheniformin into experimental animals causes rapid release of histamine from tissues [4] .

/1/ c, 2 acetone. /2/ c, 1 chloroform. /3/ UV data inconclusive because of the possible effect of impurities.

183. LITMOCIDIN

SOURCE Proactinomyces cyaneus var. antibioticus, n. sp [1] .

NATURE Pigment [1, 2] .

MELTING POINT (°C) 144-146 (d.) [2] .

SOLUBILITY Acid form: s. alcohols, acetone, ether, amyl acetate; sl. s. water. Alkali form: s. water [2] .

STABILITY Acid stable, alkali unstable [2] .

OTHER REACTIONS Red in acid, violet in neutral, blue in alkaline solution; blue sediment with lead acetate; decolorized by Zn dust, restored by exposure to air; decolorized by bisulfite.[2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, hemolytic streptococci, and Vibrio comma in dilutions of 1:400,000-1:4,000,000; Shigella dysenteriae, Sh. paradysenteriae, 1:10,000; Salmonella typhosa, S. paratyphi, S. schottmuelleri, Escherichia coli, 1:1000.[1]

In vivo. No activity against M. pyogenes var. aureus in mice [1] .

TOXICITY LD_{50} in mice, approximately 50 mg/kg, i.p. [1] .

184. LUTEOMYCIN
(Antibiotic 289)

SOURCE Streptomyces tanashiensis, related to S. antibioticus [1] ; S. flaveolus [6] .

NATURE Basic [2] .

MOLECULAR FORMULA $C_{26}H_{33}NO_{12}$ (proposed) [3] .

CRYSTAL FORM AND COLOR HCl: orange-yellow, rhomboid [1] .

MELTING POINT (°C) HCl: 199 (d.) [1] .

UV ABSORPTION MAXIMA 215, 255-257, 430 mμ [2, 3] .

SOLUBILITY HCl: s. water, chloroform, ethanol, methanol, butyl acetate, acetone; i. ether, petroleum ether, carbon disulfide, benzene, amyl alcohol. SO_4: s. water; sl. s. ethanol, acetone.[1, 2]

STABILITY Stable [1] .

OTHER REACTIONS Color changes from orange-yellow to purple at pH 7-9; extracted into ethyl or butyl acetate at pH 7-8, back to aqueous layer at pH 2; precipitates as picrate, reineckate, helianthate and, at low temperature, crystalline citrate; positive $FeCl_3$, quinone-Na_2CO_3, H_2O_2; negative xanthoproteic, biuret, Molisch, Fehling, ninhydrin, Sakaguch [1, 2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, Hemophilus pertussis, H. influenzae, Neisseria gonorrhoeae, N. meningitidis, Bacillus subtilis, Brucella abortus, Mycobacterium avium, <1.0; Br. melitensis, Br. suis, Diplococcus pneumoniae, Streptococcus pyogenes, B. anthracis, Vibrio comma, 1-3. Shigella dysenteriae, Salmonella spp, Escherichia coli, Pseudomonas aeruginosa, Myco. tuberculosis are less sensitive [2, 4] . The in vitro action was bacteriostatic, but higher concentrations were bactericidal. Resistance did not develop readily.[4]

In vivo. Total s.c. doses of approximately 3 mg/kg protected mice against D. pneumoniae, Br. melitensis, and H. pertussis; ineffective against B. anthracis and S. paratyphi. Some activity against influenza virus in mice. [5] Suppressed development of Yoshida sarcoma cells in rats [2] .

PHARMACOLOGY LD_0 in mice, 6.25 mg/kg, i.v. or s.c.; LD_{100}, 25 mg/kg.[2] Mice tolerated oral doses of 108 mg/kg. Rapidly excreted in urine following oral administration.[5]

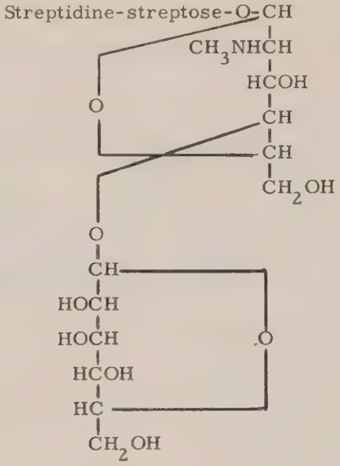
185. MANNOSIDOSTREPTOMYCIN
(Streptomycin B)

SOURCE Streptomyces griseus [1] .

NATURE Triacidic base; D-mannoside of streptomycin.[3]

MOLECULAR FORMULA AND WEIGHT $C_{27}H_{49}O_{17}N_7$ [3, 9]. Tri-HCl: 780, 820 (equiv. wt.) [1, 9].

STRUCTURE



[3, 9]

CRYSTAL FORM Reineckate: large thin plates[1] [1]. Tri-HCl: hexagonal isotropic plates [2].

MELTING POINT (°C) Anhydrous reineckate: 178-179 (d., corr.) [1, 9]. Tri-HCl: 190-200 (d.) [9].

OPTICAL ACTIVITY Tri-HCl: $[\alpha]^{25}_{D} = -47^{\circ}$[2] [1, 9]; $[\alpha]^{26.6}_{D} = -54.1^{\circ}$[3] [2].

QUANTITATIVE DETERMINATION Microbiological: Klebsiella pneumoniae [1]. Anthrone test[4] [5-7]. Carbazole in H_2SO_4[5] [4]. Spectrophotometric [8].

BIOLOGICAL ACTIVITY In vitro. Antimicrobial spectrum similar to streptomycin, but approximately 4-8 times less active than streptomycin, on a weight basis, in comparative tests with the same strains. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, 7.8-9.5; Mycobacterium tuberculosis, 3.7; Myco. smegmatis, 6.8; K. pneumoniae, 5.7; Salmonella typhosa, 12.2; S. schottmuelleri, 13.5.[10]

In vivo. Spectrum in experimental infections similar to streptomycin, but approximately 3 times less active on weight basis. Mouse protection (ED_{50}) with 9 mg/kg against S. schottmuelleri, and doses of 155 mg/kg/da afforded 100% protection against Myco. tuberculosis.[10]

TOXICITY Similar to streptomycin; LD_{50} in mice, approximately 250 mg/kg, i.v.[10]

186. MARASMIC ACID

SOURCE Marasmius conigenus [1].

NATURE Monobasic acid [1].

MOLECULAR FORMULA AND WEIGHT $C_{16}H_{20}O_4$ (proposed); 276 (calc.).[1]

CRYSTAL FORM AND COLOR Long, white needles [1].

MELTING POINT (°C) 174-175 (corr.)[6] [1].

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = +176^{\circ}$[7] [1].

UV ABSORPTION MAXIMA 240-242, 314-318 mμ[8]; 245, 246, 248, 260 mμ[9].

SOLUBILITY s. acetone, ethanol, ether, chloroform, water; i. hexane.[1]

OTHER REACTIONS pK 5.8 in 30% alcohol; reduces Fehling, ammoniacal $AgNO_3$ (when boiled); increased reducing properties at high pH; negative with hydroxylamine HCl, Br in carbon tetrachloride, alcoholic $FeCl_3$; red color with alkaline nitroprusside, changing to pale gray-green on acidification; orange-colored 2,4-dinitrophenylhydrazone, MP 136-138° (corr.).[1]

/1/ With 8.1% water of crystallization. /2/ c, 1.35 water. /3/ c, 1 water. /4/ May be preceded by ion exchange resin separation from streptomycin. /5/ Mannosidostreptomycin=purple-red color, streptomycin=yellow-brown. /6/ In sealed capillary in vacuo. /7/ c, 1.4 acetone. /8/ Ethanol. /9/ Phosphate buffer at pH 1.45-3.52, 5.4, 8.8, 11.0.

186. MARASMIC ACID (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus; antiluminescence with Photobacterium fischeri.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) P. fischeri, 0.016; Bacillus mycoides, B. subtilis, 1.0; M. pyogenes var. aureus, 2; Mycobacterium smegmatis, 32; Escherichia coli, 64; Klebsiella pneumoniae, 128; Pseudomonas aeruginosa, 250. Fungi: Trichophyton mentagrophytes, 4; Phycomyces blakesleeanus, 16; Aspergillus niger, Saccharomyces cerevisiae, Penicillium notatum, 32; Chaetomium globosum, Memnoniella echinata, Myrothecium verrucaria, 64; Stemphylium consortiale, 128; Gliomastix convoluta, 250.[1]

In vivo. No activity against Plasmodium gallinaceum infection in chicks treated with 20 mg/kg/da, i.p. [2] .

TOXICITY LD_0 in mice, 16 mg/kg, i.v.; LD_{100}, 32 mg/kg, i.v. [1]

187. MARCESIN

SOURCE Serratia marcescens [1] .

NATURE Polypeptide [1] .

UV ABSORPTION MAXIMA 240, 260 mμ [1] .

SOLUBILITY s. aqueous solvents: ethanol, isopropanol, n-butanol, acetone, dioxane, pyridine, morpholine, diethylamine, acetic acid; i. anhydrous solvents.[1]

STABILITY Thermostable; less stable in alkaline solution.[1]

OTHER REACTIONS Dialyzes through cellophane from acid solution, less readily from ammonium citrate or broth. Precipitated by picric, trichloroacetic, toluenesulfonic and tannic acids, acid dyes, nucleic acid, insulin, heparin; unaffected by pepsin, trypsin; readily lowers surface tension.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Escherichia coli [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Corynebacterium diphtheriae, <0.01; Pasteurella multocida, 0.02; Clostridium perfringens, 0.03; Micrococcus pyogenes var. aureus, 0.08-0.2; Mycobacterium tuberculosis, 0.7; Streptococcus pyogenes, Str. faecalis, 0.8-2.0; Shigella paradysenteriae, 2.0; E. coli, 3.2.[1]

In vivo. No protection in mice infected with M. pyogenes var. aureus, Str. pyogenes or Past. multocida. Injection of 1-5 mg into rabbit skin appeared to suppress M. pyogenes var. aureus local infection.[1]

TOXICITY LD_{50} in mice, 2.5 mg/kg, i.p.; 125 mg/kg, s.c. Intradermal administration of 1-5 mg induced severe necrosis at site of injection. In vitro. Red blood cells hemolyzed.[1]

188. MEDIOCIDIN

SOURCE Streptomyces mediocidicus, n. sp [1] .

FORM AND COLOR Yellow powder [1] .

UV ABSORPTION MAXIMA 339-340, 356-357, 377-378 mμ [1] .

SOLUBILITY s. methanol, ethanol; sl. s. water, acetone; i. benzene, ether, petroleum ether [1] .

BIOLOGICAL ACTIVITY Inhibits fungi (μg/ml): Penicillium chrysogenum, Sporotrichum beurmanni, Cryptococcus neoformans, 1.6; Candida albicans, C. tropicalis, 3.1; Trichophyton spp, 12.5-50; Aspergillus niger, 100. Nocardia asteroides inhibited at 100. Bacteria: Bacillus subtilis, Micrococcus pyogenes var. aureus, 25 μg/ml.[1]

In vivo. Daily i.p. doses of 10-40 μg in mice showed slight activity against Ehrlich carcinoma by inhibiting production of ascites and by slight prolongation in survival time of the animals [2] .

TOXICITY LD_{50} in mice, approximately 2 mg/kg, i.p. [1] .

189. MELLEIN
(Ochracin)

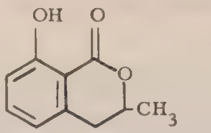
SOURCE Aspergillus melleus and A. ochraceus [3] ; by synthesis [5] .

NATURE A lactone of 6-hydroxy-2-α-hydroxypropylbenzoic acid [3] .

MOLECULAR FORMULA $C_{10}H_{10}O_3$ [1, 2] .

189. MELLEIN (Concluded)

STRUCTURE



[4, 5]

CRYSTAL FORM AND COLOR Colorless needles [1] .

MELTING POINT (°C) 58 [1, 3] ; 56-57 [4] .

OPTICAL ACTIVITY $[\alpha]_D^{12} = -108.15^\circ$[1] [2] .

UV ABSORPTION MAXIMA 212, 246, 314 mμ[2] [4] .

SOLUBILITY s. chloroform, ether, acetone, alcohol; i. water, petroleum ether [1, 2] .

OTHER REACTIONS Violet color with $FeCl_3$; yields an acetyl derivative (MP 126°C) and a nitro derivative (MP 160°C); converted to 6-hydroxy-2-methylbenzoic acid by KOH fusion.[1-3]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus [1] .

190. MESENTERIN

SOURCE Nocardia mesenterica[3] [1] .

NATURE Basic [1] .

CRYSTAL FORM AND COLOR Colorless needles[4] [1] .

MELTING POINT (°C) 122-126 [1] .

UV ABSORPTION Strong end absorption only [1] .

SOLUBILITY s. methanol, ethanol, ethyl acetate, butyl acetate, ether, benzene, acid water; sl. s. water; i. petroleum ether.[1]

STABILITY At 100°C for 30 minutes, 35% remained at pH 2, 40% at pH 4, 90% at pH 6, 22% at pH 8 [1] .

OTHER REACTIONS Analysis: C, 65.82; H, 7.10; N, 8.66, 8.44. Negative ninhydrin, Millon biuret, Tollens, Fehling, $FeCl_3$; positive Molisch.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Sarcina lutea, Micrococcus flavus at concentrations below 0.2; M. pyogenes var. aureus, 0.8-3.1; Bacillus subtilis, 1.6-3.1; Mycobacterium sp, 6.3. Escherichia coli, Salmonella paratyphi, Proteus vulgaris not sensitive to 50.[1]

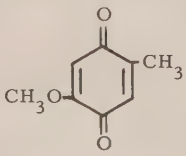
TOXICITY LD_{50} in mice, >100 mg/kg, parenterally [1] .

191. 5-METHOXY-p-TOLUQUINONE

SOURCE Coprinus similis and Lentinus degener [1] .

MOLECULAR FORMULA $C_8H_8O_3$ [1] .

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Golden-yellow plates or clusters of short prisms [1] .

MELTING POINT (°C) 170-172 [1] .

/1/ Chloroform. /2/ Ethanol. /3/ This culture also produces azomycin and antibiotic 446. /4/ From benzene.

191. 5-METHOXY-p-TOLUQUINONE (Concluded)

SOLUBILITY sl. s. water, saline [1] .

OTHER REACTIONS Characteristic aromatic odor; bright orange-red in concentrated H_2SO_4; in alkaline solution darkens rapidly to a purplish-brown; reacts with carbonyl reagents; takes up Br in CCl_4; yields purple crystalline derivative with aniline; gives blue-violet color changing to blue-green, and finally reddish-brown with ethyl cyanoacetate and ammoniacal ethanol. (Other reactions and products are reported in reference [1] as typical of this compound.) [1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY Active against bacteria and fungi. In vitro. Inhibits (μg/ml) M. pyogenes var. aureus, 0.5-1.0; Bacillus subtilis, 2-4; B. mycoides, Klebsiella pneumoniae, 16-64; Mycobacterium smegmatis, 64-128; Escherichia coli, 31-128; Pseudomonas aeruginosa, 128-256. Fungi: Trichophyton mentagrophytes, 4; Aspergillus niger, Chaetomium globosum, 16; Memnoniella echinata, Phycomyces blakesleeanus, 32; Gliomastix convoluta, Myrothecium verrucaria, Stemphylium consortiale, 64; Penicillium notatum, 128. 50% loss of in vitro activity in presence of blood.[1]

TOXICITY LD_{50} in mice, approximately 25 mg/kg, i.v. [1]

192. 6-METHYL-1,4-NAPHTHAQUINONE

SOURCE Marasmius graminum [1] .

MOLECULAR FORMULA $C_{11}H_8O_2$ [2] .

CRYSTAL FORM AND COLOR Golden yellow needles[1] [2] .

MELTING POINT (°C) 90-91 [2] .

SOLUBILITY sl. s. water [1] .

OTHER REACTIONS Yellow aqueous solution, turning violet if alkali is added; at first red needles (MP 87-88°C), recrystallized from petroleum ether, are obtained, then use of acid-washed alumina column gives yellow needles; degradation of red compound gives trimellitic acid.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1, 2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus [1] .

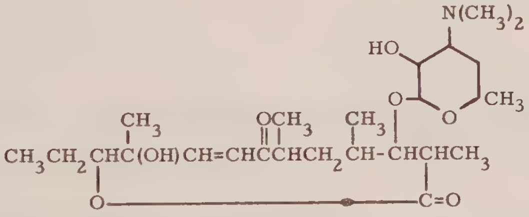
193. METHYMYCIN

SOURCE Streptomyces sp [1] .

NATURE Basic [1] .

MOLECULAR FORMULA AND WEIGHT $C_{25}H_{43}O_7N$ (proposed); 469 (neut. equiv.); 469.6 (calc.).[1, 4]

STRUCTURE



[6]

CRYSTAL FORM AND COLOR Colorless prisms[2]; needles[3] [1] .

MELTING POINT (°C) 195.5-197[4] [1, 4] .

OPTICAL ACTIVITY $[\alpha]_D = +61°^5, +74°^6$.[1]

UV ABSORPTION MAXIMA 223, 322 mμ[5] [1] .

/1/ Recrystallized from dilute acetic acid. /2/ Purified. /3/ Less pure. /4/ A second MP reported for a polymorphic variation: 203-205°C. /5/ Methanol. /6/ Chloroform.

193. METHYMYCIN (Concluded)

SOLUBILITY Free base: s. methanol, acetone, chloroform, aqueous acid; less s. ethanol, ether; i. water, hexane. Sulfate salts: s. methanol, water. Hydrogen sulfate base: s. acetone.[1]

OTHER REACTIONS Similar to picromycin and the proactinomycins; decolorizes permanganate in acetone solution; absorbs Br in carbon tetrachloride solution; negative Molisch, biuret, ninhydrin, $FeCl_3$.[1] Similarity also to narbomycin, carbomycin, and erythromycin [4, 5] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Klebsiella pneumoniae, 3.2; Diplococcus pneumoniae, 6-50; Corynebacterium diphtheriae, Brucella abortus, Clostridium septicum, Streptococcus pyogenes, 10-20; Micrococcus pyogenes var. aureus, 40. The following required 312-1875 μg/ml: Str. faecalis, Shigella sonnei, Aerobacter aerogenes, Bacillus subtilis, Pseudomonas aeruginosa, Salmonella spp, Proteus vulgaris. Fungi not sensitive to 1000 μg/ml.[1]

In vivo. No activity in experimental toxoplasmosis in mice treated with 2 mg, s.c. [2] .

CLINICAL Used in 4 cases of acute brucellosis (Br. melitensis) in man. 1.5-2.0 g/da in 3 divided doses had some suppressive effect on infection, but was not curative. These doses, continued up to 34 days, appeared to be well tolerated.[3]

194. MICROCINS

SOURCE Micromonospora sp [1] .

NATURE Microcin A: neutral.
B: acidic.[1]

CRYSTAL FORM AND COLOR Microcin A: reddish-purple powder.
B: yellowish-red powder.[1]

SOLUBILITY Microcin A: s. ethyl acetate; i. water.
B: s. ethyl acetate; sl. s. water.[1]

OTHER REACTIONS Negative Molisch, $FeCl_3$ [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibit Micrococcus pyogenes var. aureus in dilution of 1:2000; Bacillus subtilis, 1:1000; Escherichia coli, Proteus vulgaris, 1:100; Mycobacterium avium, 1:50. Low activity against fungi: Aspergillus oryzae, Penicillium sp, Saccharomyces sp [1] .

TOXICITY LD_{50} in mice, 6.25 mg/kg, i.v. [1] .

195. MICROCOCCIN

SOURCE Micrococcus sp, resembling M. varians [1] .

MOLECULAR FORMULA AND WEIGHT Possibly $C_{25}H_{28}O_6N_6S_3$; 2170-2720 (Barger).[2]

CRYSTAL FORM AND COLOR Fine, long, silky, white needles in fans, sheaves or balls; birefringent.[2]

MELTING POINT (°C) 222-228 (sinters) [2] .

OPTICAL ACTIVITY $[\alpha]^{21}_{D} = +116^\circ \pm 1$[1] [2] .

UV ABSORPTION MAXIMUM 345 mμ[2] [2] .

SOLUBILITY s. alcohol, acetone, chloroform, propylene glycol, glacial acetic acid, pyridine; sl. s. water; i. ether, benzene, amyl acetate, glycerine, vegetable oils.[1, 2]

STABILITY Thermostable; alkali labile.[1, 2]

OTHER REACTIONS Dialyzes through cellophane; positive ninhydrin only after acid hydrolysis; unaffected by trypsin, pepsin, cysteine, fluorescence and UV absorption reduced by traces of Cu, partly restored by BAL.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis. Fluorescence. UV absorption.[3]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Streptococcus spp, B. subtilis, B. anthracis, Corynebacterium diphtheriae, Clostridium spp, Mycobacterium tuberculosis, Vibrio comma, 6 μg/ml or less. Gram-negative bacteria not sensitive to 1000 μg/ml, e.g., Pseudomonas aeruginosa, Escherichia coli,

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/1/ Ethanol. /2/ With blue or purple fluorescence.

195. MICROCOCCIN (Concluded)

Salmonella typhosa. In vitro action primarily bacteriostatic rather than bactericidal.[1] Slightly retarded growth of intracellular Myco. tuberculosis within rabbit macrophages. Under same test conditions, streptomcyin and other antitubercular agents were highly active.[4]

In vivo. Slight protection afforded against Str. pyogenes infection in mice [5] . In experimental tuberculosis of guinea pigs and rabbits, i.v. administration delayed but did not prevent lesions in the spleen and liver. The antibiotic did not penetrate tubercles in a significant amount.[6]

PHARMACOLOGY This almost insoluble antibiotic, after i.v. administration, enters and remains in phagocytic cells for many months without apparent cytotoxicity [7] . Immediately following i.v. injection, micrococcin (solubilized in synthetic detergent "Triton") was detected in high concentrations in the lungs and in 2-3 days within the cells of the reticuloendothelial system, especially the spleen and liver. Repeated larger i.v. doses damaged renal glomeruli.[5]

RESISTANCE Myco. tuberculosis, micrococci, streptococci, and Actinomyces rapidly developed resistance in vitro [1] .

196. MICROMONOSPORIN

SOURCE Micromonospora sp [1] .

NATURE Pigmented protein [1] .

STABILITY Thermolabile; unstable below pH 3 and above pH 9 [1] .

OTHER REACTIONS Protein associated with a carbohydrate in culture filtrates; non-dialyzable; positive Molisch; negative phloroglucinol, orcinol, naphthoresorcinol, unaffected by pepsin, trypsin; precipitated by saturated ammonium sulfate.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Bacillus subtilis, B. mycoides, Sarcina lutea. Gram-negative bacteria not sensitive.[1]

197. MOLDIN

SOURCE Streptomyces phaeochromogenus [1] .

UV ABSORPTION MAXIMUM 370 mμ [1] .

SOLUBILITY s. ethanol, ethyl acetate; sl. s. petroleum ether, ether, benzol; i. water.[2]

OTHER REACTIONS Can be adsorbed on alumina from ethyl acetate but not eluted; positive Molisch, $FeCl_3$; negative biuret, ninhydrin, Tollens, Fehling, Sakaguchi.[1, 2]

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Trichophyton spp, Histoplasma capsulatum, Cryptococcus neoformans, 0.4-1.5; Candida spp, 0.4-50.0. No activity against bacteria.[1, 2]

TOXICITY LD_{100} in mice, approximately 10 mg/kg, i.p. [2] .

198. MUSARIN

SOURCE Streptomyces sp [1] .

NATURE An acid [1] .

MOLECULAR FORMULA AND WEIGHT $(C_{35}H_{60}O_{14}N_2)_n$ (proposed); approximately 5000.[1]

FORM AND COLOR Light yellow powder [1] .

MELTING POINT (°C) 170 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]_D^{20} = +35.1^\circ \pm 1.6$ [1]; $+38.7^\circ \pm 2.7$ [2].[1]

UV ABSORPTION MAXIMA 240, 267 mμ[3] [1] .

SOLUBILITY Free acid: s. aqueous acetone and alcohol; i. water, dry acetone. Na or K salt: s. water, methanol, ethanol, butanol; i. ether, acetone.[1]

STABILITY Thermolabile; free acid unstable at room temperature; Na salt more stable.[1]

/1/ c, 1.21 methanol. /2/ c, 0.736 methanol. /3/ Ethanol.

198. MUSARIN (Concluded)

OTHER REACTIONS Precipitated by mineral acids, barium chloride, mercuric chloride, copper acetate; negative Molisch, Millon, biuret, H_2SO_4 in acetic acid or with I, Salkowski, Liebermann, murexide; weak or negative ninhydrin; positive Axenfeld; inactivated product with diazomethane or methanolic HCl.[1]

QUANTITATIVE DETERMINATION Microbiological: Fusarium oxysporium var. cubense [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Streptococcus pyogenes in dilution of 1:25,000; Micrococcus pyogenes var. aureus, Bacillus subtilis, Mycobacterium phlei, 1:100,000-1:500,000. Phytopathogenic fungi: Botrytis cinerea, Verticillium spp, Ceratostomella paradoxa, Corticium solani, Sclerotinia fructigena, Melanospora destruens, Alternaria sp, 1:400,000-1:800,000; Fusarium spp, Rhizopus stolonifer, Aspergillus niger, Penicillium notatum, 1:50,000-1:100,000.[1]

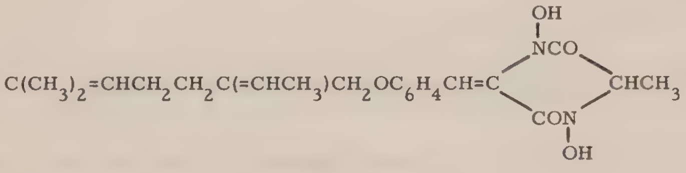
199. MYCELIANAMIDE

SOURCE Penicillium griseofulvum [1] .

NATURE An amide of o-mycelyl-N-pyruvyl-β-ketotyrosine [1] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{28}O_5N_2$; 400.5 (cryo.); 400 (calc.).[1]

STRUCTURE



[3]

CRYSTAL FORM AND COLOR Shiny colorless leaflets [1] .

MELTING POINT ($^{\circ}$C) 170-172 (d.) [1] ; 171 [3] .

OPTICAL ACTIVITY $[\alpha]_{5461}^{19} = -217^{\circ}$[1]; $[\alpha]_{5790}^{19} = -182^{\circ}$[1].[1]

SOLUBILITY s. acetone, dioxane, sodium carbonate solution; sl. s. ethanol, chloroform, ether, benzene, glacial acetic acid; i. dilute sodium bicarbonate, barium hydroxide, HCl.[1]

STABILITY Thermostable; acid and alkali unstable.[1]

OTHER REACTIONS In cold dilute NaOH, antibiotic foams and darkens, producing a lavender-like odor; ferric salt reddish-brown, copper salt green, nickel salt yellow-silver turning to black, all being insoluble; negative Millon, murexide, biuret, p-dimethylaminobenzaldehyde; no picrate or methiodide; red-brown with dilute $FeCl_3$ in ethanol or glacial acetic acid.[1] Acid hydrolysis yields alanine [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, M. pyogenes var. albus, Bacillus anthracis, Streptococcus pyogenes in dilution of 1:20,000-1:50,000. Inactive against Gram-negative bacteria.[1]

200. MYCELIN

SOURCE Streptomyces roseoflavus [1] .

CRYSTAL FORM Prisms[2] [2] .

MELTING POINT ($^{\circ}$C) 260 (blackens); 263 (d., uncorr.).[1]

SOLUBILITY s. chloroform, butanol, methanol, ethanol, amyl alcohol, acetone, benzene; i. water, ether, petroleum ether.[1]

STABILITY Thermostable; stable in acetone at pH 2, 7, and 8.8 for 24 hours.[1]

OTHER REACTIONS Negative Molisch [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Penicillium spp, 0.5-1.0; Mycoderma sp, Aspergillus niger, 1.25; Torula rubra, Trichophyton interdigitale, 2.5; A. oryzae, Oidium lactis, 5; Mucor mucedo, Saccharomyces saké, Candida albicans, 10; T. purpureum, 12.5; Cryptococcus spp, 5-10. No activity against bacteria.[1, 2]

/1/ c, 0.8688 chloroform. /2/ From acetone.

200. MYCELIN (Concluded)

In vivo. Topical application of 0.005% hydrophilic ointment effective in experimental skin mycoses (T. purpureum) in guinea pigs [2] .

201. MYCOCIDIN

SOURCE Aspergillus sp [1] .

NATURE Acidic [1] .

SOLUBILITY Salts: s. water, alkali; i. acid. Acid precipitate: s. ether, chloroform, ethyl acetate; i. water [1] .

STABILITY Thermostable [1] .

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium tuberculosis var. hominis [2] .

BIOLOGICAL ACTIVITY *In vitro.* Inhibits Myco. tuberculosis var. hominis. Exposure of these cultures to mycocidin rendered them non-infective to guinea pigs.[2]

202. MYCOLUTEIN

SOURCE Streptomyces sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{24}NO_6$ (proposed); 417, 495.[1]

CRYSTAL FORM AND COLOR Bright yellow tablets[1] [1] .

MELTING POINT (°C) 157-158 [1] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = +54^\circ$[2] [1] .

UV ABSORPTION MAXIMA 254, 345 mμ [1] .

SOLUBILITY s. chloroform, acetone, lower alcohols, benzene, 1,4-dioxane, pyridine, glacial acetic acid; less s. ethyl acetate, carbon tetrachloride, ether, petroleum ether; i. water, dilute HCl, Na_2CO_3.[1]

STABILITY Decomposed by aqueous NaOH; stable in boiling methanol for at least 10 minutes at pH 5.1-8.2, but decomposed rapidly at higher or lower pH values even in cold.[1]

OTHER REACTIONS Found in mycelium; dissolves in concentrated H_2SO_4, with an olive color that turns rapidly to dark red; decolorizes $KMnO_4$ in acetone in cold, and a solution of Br in methanol with the evolution of HBr; positive test for aromatic nucleus with anhydrous aluminum chloride and chloroform; negative $FeCl_3$, acetylation with acetic anhydride in pyridine; on standing at room temperature, in equal volumes of concentrated HCl and either methanol or dioxane, the UV peaks disappear and one at 265 mμ appears, one of the degradation products being an acid.[1]

BIOLOGICAL ACTIVITY *In vitro.* Inhibits the following fungi (μg/ml): Candida stellatoidea at 0.2; C. albicans, C. tropicalis, Trichophyton mentagrophytes, 0.4; C. guillermondii, T. rubrum, Microsporum gypseum, 0.7; Cryptococcus neoformans, 1.4. Bacteria not sensitive. In vitro antifungal activity diminished in media containing glucose or other sugars.[1]

TOXICITY Mice tolerated 5 mg/kg, i.p.; 25 mg/kg were lethal [1] .

203. MYCOMYCIN

SOURCE Nocardia acidophilus [4] .

NATURE Highly unsaturated carboxylic acid [3] .

MOLECULAR FORMULA AND WEIGHT $C_{13}H_{10}O_2$ [1, 2] ; 200 (neut. equiv. found); 198 (calc.).[1]

STRUCTURE $HC\equiv C-C\equiv CCH=C=CHCH=CHCH=CHCH_2CO_2H$ [1, 3] .

CRYSTAL FORM AND COLOR Colorless needles [1, 2] .

MELTING POINT (°C) 75 (d. explosively) [1-3] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -130^\circ$[3] [1-3] .

/1/ Recrystallized from methanol and benzene. /2/ c, 1 chloroform. /3/ c, 0.4 ethanol.

203. MYCOMYCIN (Concluded)

UV ABSORPTION MAXIMA 267, 281 mμ [1,3] .

STABILITY Extremely unstable [2] .

OTHER REACTIONS Undergoes rearrangement in normal aqueous KOH at 27°C, forming 3,5-tridecadiene-7,9,11-triynoic acid (isomycomycin); decomposition prevents salt formation; reacts rapidly with oxidizing reagents, yielding dark resinous products; heavy precipitate with alcoholic $AgNO_3$; series of color reactions with liquid ammonia. [1-3]

QUANTITATIVE DETERMINATION Microbiological: Bacillus mesentericus, B. subtilis [2] .

BIOLOGICAL ACTIVITY In vitro. Crude preparations inhibited Mycobacterium tuberculosis in dilution of 1:5000; B. subtilis, 1:7500.[4] Purer preparations inhibited (units/ml) Myco. tuberculosis, Brucella abortus, Micrococcus pyogenes var. aureus, Salmonella typhosa, Cryptococcus neoformans, Candida albicans, 1-5; S. paratyphi, S. schottmuelleri, 8-10; Pseudomonas aeruginosa, >640.[5]

In vivo. Earlier preparations gave good protection in experimental tuberculosis in guinea pigs treated with 5000 units/da [5] . Crystalline preparations gave no protection [6] .

PHARMACOLOGY Hemolytic in vitro and in vivo. Very low concentrations in blood following i.m. or i.v. administration of 10,000-40,000 units/kg in rabbits and guinea pigs. Apparently unstable in vivo.[6,7]

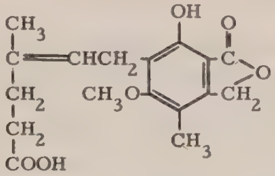
204. MYCOPHENOLIC ACID

SOURCE Penicillium brevi-compactum and related spp [1,3] .

NATURE Weak dibasic acid [2,3] .

MOLECULAR FORMULA AND WEIGHT $C_{17}H_{20}O_6$ [2,3,6] ; 314-360 (found); 320.2 (calc.).[2,3,5]

STRUCTURE



[4,6]

CRYSTAL FORM AND COLOR Radiating colorless needles [2-4] .

MELTING POINT (°C) 141 [2,3,5] .

OPTICAL ACTIVITY Inactive [2,3] .

SOLUBILITY s. alcohol, ether, chloroform; less s. benzene, cold toluene; i. cold water.[3]

STABILITY Thermo-, acid, and alkali stable [2,3] .

OTHER REACTIONS Intense blue color with $FeCl_3$; Pb, Ag, Cu salts amorphous and insoluble in water; disodium and dipotassium salts soluble in water, but only the latter is insoluble in absolute alcohol; heavy precipitate with Br water; no reaction with bleaching powder; negative Fehling, ammoniacal $AgNO_3$; oxidized by permanganate in cold. [2,3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, Corynebacterium xerose, Bacillus subtilis in dilution of 1:1,000-1:20,000; C. michiganense, C. sepedonicum, 1:160,000-1:320,000. Streptococcus pyogenes, Salmonella typhosa, Escherichia coli not sensitive to 1:1,000. Phytopathogenic fungi: Claviceps purpurea, Phytophthora erythroseptica, Rhizoctonia crocorum, Verticillium dahliae, Stereum purpureum, 1:20,000-1:80,000.[1,7] M. pyogenes var. aureus rapidly acquired resistance in vitro. Activity reduced by serum.[1]

PHARMACOLOGY LD_{100} in mice, 500 mg/kg, i.v.; 2000 mg/kg, oral; s.c. doses of 500 mg/kg tolerated. In vitro. Toxic to leukocytes in dilution of 1:200. Absorbed from s.c. tissues and upper gastrointestinal tract; very small amount excreted in urine, hence apparently inactivated in tissues.[1]

205. MYCOSUBTILIN

SOURCE Bacillus subtilis [1] .

205. MYCOSUBTILIN (Concluded)

FORM AND COLOR White crystals [1].

MELTING POINT (°C) 256-257 (corr.) [1].

UV ABSORPTION MAXIMUM 277 mμ[1] [1].

SOLUBILITY s. pyridine, 70% ethanol, dilute NaOH; i. dilute HCl and $NaHCO_3$, other solvents.[1]

STABILITY Thermostable [1].

OTHER REACTIONS Analysis: C, 55.31, 55.12; H, 7.61, 7.33; N, 15.15, 15.18. Acid hydrolysis yields several amino acids; negative 2,4-dinitrophenylhydrazine, Fehling, $FeCl_3$; positive Millon, nitric acid, ninhydrin (acid hydrolysates).[1]

QUANTITATIVE DETERMINATION Microbiological: Trichophyton sp [1].

BIOLOGICAL ACTIVITY In vitro. Inhibits yeasts and fungi (μg/ml): Torulopsis delbruckii, Hansenula anomala, Dipodascus uninucleatus, 3.75; Torula cremoris, Rhodotorula rubra, Saccharomyces carlsbergensis, 7.5; Debaryomyces gruetzii, Candida guilliermondi, >20; Trichophyton sp, Sclerotinia fructicola, Ustilago zeae inhibited at 1.5-2.5; Epidermophyton inguinale, Cryptococcus neoformans, Achorion schoenleinii, Microsporum audouini, Nematospora coryli, 5.0-7.5; T. mentagrophytes, M. lanosum, 10; Trichoderma sp, >20.[1] Also inhibits Torula utilis, Aspergillus niger, 6.2; Absidia orchidis, Mucor pusilis, 12.5; Candida albicans, C. krusei, Botrytis sp, Trichophyton interdigitale, 100.[2] Relatively inactive against bacteria, but Micrococcus lysodeikticus sensitive to 16 μg/ml. In vitro activity depressed by serum.[1]

TOXICITY LD_0 in mice, 12.5 mg/kg, s.c.; LD_{100}, 25-50 mg/kg, s.c.[1]

206. MYCOTICIN

SOURCE Streptomyces ruber [1].

MOLECULAR FORMULA $C_{18}H_{30}O_5$ (proposed) [1].

FORM AND COLOR Yellow crystals [1].

UV ABSORPTION MAXIMA 363, 263, 210 mμ [1].

SOLUBILITY s. lower alcohols, propylene glycol, diethylene glycol, H_2SO_4, phosphoric acid; partly s. water, benzene, acetone; i. ether, petroleum ether, xylene, chloroform.[1]

STABILITY Thermo- and acid stable; unstable to UV and as crystalline material in dark.[1]

OTHER REACTIONS Infrared: In mineral oil, strong OH band at 3.1 μ, medium bands at 5.94, 6.2, 6.34 μ; in pyridine, broad bands at 3.2-3.6, 5.9-6.4 μ; fluoresces in UV; dialyzable; negative Br, $KMnO_4$; positive Brady; reduces ammoniacal $AgNO_3$, Fehling; most antifungal activity at alkaline pH.[1]

QUANTITATIVE DETERMINATION: Microbiological: Sporotrichum schenckii [1].

BIOLOGICAL ACTIVITY Active against fungi. In vitro. Inhibits (μg/ml) Histoplasma capsulatum, S. schenckii, Coccidioides immitis, Microsporum audouini, 1-3; Blastomyces dermatitidis, 2-4; Trichophyton rubrum, 3-5; M. canis, 4-7; T. mentagrophytes, 5-9; M. gypseum, 8-10; Cryptococcus neoformans, 6-8; Hormodendrum pedrosoi, 7-10; Candida albicans, 6-10. Bacteria and protozoa not sensitive to 100 μg/ml, e.g., Escherichia coli, Bacillus subtilis, Streptococcus pyogenes, Salmonella typhosa, Entamoeba histolytica, Leishmania donovani.[1]

TOXICITY LD_{50} in mice, 10-20 mg/kg, i.p.; >100 mg/kg, s.c. Necrosis at site of s.c. injection of 100 mg/kg. Hemolyzes red blood cells in vitro, but no evidence of this in vivo.[1]

207. NARBOMYCIN

SOURCE Streptomyces narbonensis, n. sp [1].

MOLECULAR FORMULA AND WEIGHT $C_{28}H_{47}O_7N$; 502, 514 (found); 509.66 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless crystals [1].

MELTING POINT (°C) 113.5-115 [1].

/1/ Alcohol-water.

207. NARBOMYCIN (Concluded)

OPTICAL ACTIVITY $[\alpha]_D = +68.5^{\circ 1}$ [1] .

UV ABSORPTION MAXIMA 225, 286 mμ [1] .

OTHER REACTIONS Infrared: Bands at 1730, 1689, 1629 recip. cm in the 6 μ region; on hydrogenation in presence of palladium takes up 1 mole of H forming crystalline dihydro derivative ($C_{28}H_{49}O_7N$, MP 96-99, $[\alpha]_D = +26^\circ$ in chloroform); hydrolysis with 1 N HCl yields a base as a hydrochloride which resembles the desosamine HCl obtained by hydrolysis of picromycin and erythromycin ($C_8H_{18}O_3N\ Cl$, MP 185-187°); cross resistance of a strain of Micrococcus pyogenes var. aureus to narbomycin and picromycin; culture fluids produce at least 3 antibiotics extractable with organic solvents.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Streptococcus pyogenes, 0.1-1.0; Corynebacterium diphtheriae, 1; Str. mitis, Bacillus megatherium, 10; Micrococcus pyogenes var. aureus, 10-100; Str. faecalis, 100. Not sensitive (100 μg/ml): Escherichia coli, Salmonella typhosa, S. schottmuelleri, Shigella sonnei, Pseudomonas aeruginosa, Klebsiella pneumoniae, Pasteurella pestis, Vibrio comma, Candida albicans, C. tropicalis.[1]

In vivo. No activity in mice infected with Str. pyogenes [1] .

ACUTE TOXICITY Mice tolerated s.c. doses of 500 mg/kg [1] .

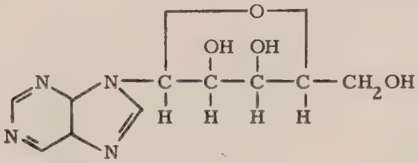
208. NEBULARINE
(9-(β-D-Ribofuranosyl)purine)

SOURCE Clitocybe nebularis (Batsch) [1] , and by synthesis [2] .

NATURE Furanoside; neutral.[1, 4]

MOLECULAR FORMULA $C_{10}H_{12}N_4O_4$.

STRUCTURE



[4]

CRYSTAL FORM Long prisms, small rhombohedral crystals [2, 4] .

MELTING POINT (°C) 181-182 (corr.) [2-4] .

OPTICAL ACTIVITY $[\alpha]^{25}_D = -48.6^{\circ 2}, -61^{\circ 3}, -22^{\circ 4}; [\alpha]^{20}_D = -47.5^{\circ 5}, -47.3^{\circ 2}$.[2, 4]

UV ABSORPTION MAXIMUM 263 $m\mu^6$ [2, 4] .

SOLUBILITY s. water (8.9%), methanol (0.5%), at 25°C; sl. s. cold ethanol; i. ether, chloroform, acetone.[1, 4]

STABILITY Thermostable [1, 4] .

OTHER REACTIONS Precipitates with Reinecke's salt; positive Molisch; splits into a purine and D(-)ribose on hydrolysis; fairly stable in dilute ammonia solutions, but less so in aqueous solutions of diethylamine, piperidine, mineral acids.[1, 4]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium avium [4] .

BIOLOGICAL ACTIVITY Active against mycobacteria. In vitro. Inhibits Myco. tuberculosis var. hominis, Myco. tuberculosis var. bovis, Myco. avium and Myco. phlei in dilution of 1:500, 000-1:3, 000, 000. No activity against Bacillus subtilis, Sarcina lutea, Micrococcus pyogenes var. aureus, Escherichia coli, Aerobacter aerogenes, Proteus vulgaris.[4]

In vivo. Daily i.p. doses of 5 mg/kg in mice had a moderate suppressive effect on an ascites tumor (sarcoma 180) [6] .

TOXICITY LD_{50} s.c. in mice, 200 mg/kg; in rats, 220 mg/kg; in guinea pigs, 15 mg/kg. Mice tolerated single i.v. doses of 200 mg/kg, and guinea pigs 60 mg/kg, i.v.[5] Rabbits tolerated daily i.v. doses of 30 mg for 7 days [4] . In anesthetized dogs, antibiotic caused transient fall in blood pressure; caused reduction in tone of rabbit ileum and spasm of guinea pig uterus [5] . In vitro. Red blood cells hemolyzed by concentrations of 5 mg/ml. Growth of barley seedlings inhibited by dilution of 1:3000; toxic to onion root tips at 1:10, 000-1:100, 000.[4]

/1/ c, 1.35 chloroform. /2/ c, 1 water. /3/ c, 0.8 0.1 N NaOH. /4/ c, 0.8 0.1 N HCl. /5/ c, 2 water. /6/ Water.

209. NEMOTIN

SOURCE Poria corticola and P. tenuis [1] .

NATURE Acetylenic; neutral.[1, 2]

OPTICAL ACTIVITY $[\alpha]_D^{23} = +202^{\circ 1}$ [1] .

UV ABSORPTION MAXIMA 207, 236, 248, 262, 276 $m\mu^2$ [2] .

SOLUBILITY s. ether, chloroform, acetone, methyl isobutyl ketone; sl. s. water, hexane [1] .

STABILITY Stable in acid aqueous solution [1] .

OTHER REACTIONS Drying produces a brown inactive product; changes to active nemotin A above pH 6. UV of nemotin A in phosphate buffer at pH 7: 231, 242, 257.8, 272, 289, 307, 328 mμ.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, 0.1; Mycobacterium smegmatis, 1.0; Myco. tuberculosis, 7; M. pyogenes var. aureus, 2; Escherichia coli, Klebsiella pneumoniae, 32; Pseudomonas aeruginosa, 250. Fungi (0.03-4.0 μg/ml): Penicillium notatum, Phycomyces blakesleeanus, Memnoniella echinata, Myrothecium verrucaria, Aspergillus niger, Chaetomium globosum, Saccharomyces cerevisiae, Trichophyton mentagrophytes. Nemotin A, in general, is less active on a weight basis.[1]

TOXICITY LD_{50} in mice, approximately 125 mg/kg, i.v. [1] .

210. NEMOTINIC ACID

SOURCE Same as nemotin [1] .

NATURE Acetylenic; monobasic acid [1, 2] .

MOLECULAR WEIGHT 205 (equiv. wt.) [1] .

OPTICAL ACTIVITY $[\alpha]_D^{23} = +270^{\circ 3}$ [1] .

UV ABSORPTION MAXIMA 208, 237, 249, 263, 277 $m\mu^2$ [2] .

SOLUBILITY s. ether, chloroform, acetone, methyl isobutyl ketone; sl. s. water, hexane.[1]

STABILITY Stable at room temperature for 1 hour at pH 3.6-9.4 [1] .

OTHER REACTIONS Inactive when dried in air at room temperature; major change at pH 12.6.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Same antibacterial spectrum as nemotin, but less active against fungi [1] .

211. NEOCIDIN

SOURCE Certain strains of Bacillus subtilis [1] .

FORM AND COLOR Light yellow powder [1] .

SOLUBILITY s. methanol, water; sl. s. ethanol; i. acetone, n-butanol, ether, petroleum ether, amyl acetate.[1]

STABILITY Thermolabile; most stable at pH 5.0-6.4.[1]

OTHER REACTIONS 1% aqueous solution faintly opalescent; negative biuret, Ehrlich aldehyde; larger diffusion zones at pH 8 than at 7; light-sensitive.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus in dilution of 1:64,000-1:256,000; Vibrio comma, 1:64,000; Bacillus anthracis, 1:128,000; Mycobacterium avium, 1:32,000; Salmonella spp, 1:4000-1:8000.[1]

TOXICITY LD_0 in mice, 660 mg/kg, i.v.; 1900 mg/kg, s.c. [1]

/1/ c, 1.2 ethanol. /2/ Water. /3/ c, 0.44 ethanol.

212. NEOMYCINS
(Flavomycin)
The trademark of The Upjohn Company for neomycin is Mycifradin.

SOURCE Streptomyces fradiae [1] , and other Streptomyces spp [62] .

NATURE Basic [1, 2, 5] .

MOLECULAR FORMULA AND WEIGHT Neomycin A: $C_{12}H_{26}N_4O_6$ [11] .
B, C: $C_{23}H_{46}N_6O_{12}$ or $C_{23}H_{48}N_6O_{13}$ [64] ; 507-669 (ebull. in methanol); 616.7 (calc.).[64]

FORM AND COLOR Neomycin A HCl: white, amorphous powder. Base: white.[4, 11]

MELTING POINT (°C) Neomycin A: 256 (d.) [10] .

OPTICAL ACTIVITY Neomycin A base: $[\alpha]^{25}_{D} = +112.8^{\circ}$[1], or 123.5° [11] . HCl: $[\alpha]^{25}_{D} = +83^{\circ}$[1] [4, 9] .

B base: $[\alpha]^{25}_{D} = +71^{\circ}$[2], $+83^{\circ}$[3].[64] HCl: $[\alpha]^{25}_{D} = +63^{\circ}$[4] [64] , $+54^{\circ}$[5] [9] . Sulfate: $[\alpha]^{25}_{D} = +56^{\circ}$[6] [64] .

C base: $[\alpha]^{25}_{D} = +110^{\circ}$[2], $+121^{\circ}$[6] [64] . HCl: $[\alpha]^{25}_{D} = +88^{\circ}$[4] [64] , $+80^{\circ}$[5] [9] . Sulfate: $[\alpha]^{25}_{D} = +82^{\circ}$[6] [64] .

UV ABSORPTION MAXIMUM End absorption only [4] .

SOLUBILITY s. water; sl. s. methanol; i. other organic solvents.[1, 3]

STABILITY Thermo-, acid, and alkali stable [1, 3] .

OTHER REACTIONS Neamine and neomycin A are identical; positive ninhydrin, Molisch, carbazole; negative glucosamine, Tollens, Elson-Morgan; crystalline salts with p-hydroxyazobenzene-p'-sulfonic acid, ammonium reineckate; amorphous hydrochloride and sulfate salts; cysteine slightly reduces activity; yields furfural on acid hydrolysis; all N present as primary amino groups.[1-5, 9, 12] B and C yield equimolar amounts of neamine and the respective methyl neobiosaminides on methanolysis [64] . Streptothricin BII identical with Neomycin B, and streptothricin BI with neomycin C [63] .

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli, Bacillus subtilis [5-9] . Colorimetric [4, 7] .

BIOLOGICAL ACTIVITY Active primarily against Gram-negative and Gram-positive bacteria (including mycobacteria) and actinomycetes; little or no activity against yeasts, filamentous fungi, viruses or protozoa. Wide variation in sensitivity between strains of same species of bacteria. In vitro. In general, most strains of the following inhibited by 0.2-10.0 μg/ml: Aerobacter aerogenes, B. anthracis, B. subtilis, B. cereus, B. mycoides, Brucella abortus, Br. melitensis, Br. suis, Corynebacterium diphtheriae, Corynebacterium spp, E. coli, Klebsiella pneumoniae, Listeria monocytogenes, Micrococcus pyogenes var. aureus, M. lysodeikticus, Mycobacterium avium, Myco. leprae, Myco. phlei, Myco. ranae, Myco. tuberculosis, Pasteurella multocida, Pseudomonas aeruginosa, Salmonella schottmuelleri, Shigella dysenteriae, Sh. paradysenteriae, Sh. sonnei, Sarcina lutea, Serratia marcescens. Generally inhibited by 10-50 μg/ml: Diplococcus pneumoniae, Hemophilus pertussis, Proteus vulgaris, Salmonella typhosa, Streptococcus pyogenes, Str. viridans, Neisseria gonorrhoeae, N. meningitidis. H. influenzae, Malleomyces mallei, Clostridium perfringens, Clostridium spp, Salmonella paratyphi, Vibrio comma, >50 μg/ml. Actinomycetes: Streptomyces antibioticus, S. coelicolor, S. fradiae, S. lavendulae inhibited by <3 μg/ml. Spirochetes and protozoa (μg/ml): Borrelia recurrentis, Leptospira icterohemorrhagiae, 2.5; Entamoeba histolytica, 42-165; Leishmania donovani, Trypanosoma cruzi, 3000; Trichomonas vaginalis, >300.[12-18] Concentration of 25 μg/ml in vitro bacteriostatic to Myco. tuberculosis within rabbit macrophages [19] . Inhibits bovine strains of Cryptococcus neoformans at 25 μg/ml [65] . Trichomonas foetus and T. gallinae are not sensitive [66] . Neomycin A (neamine), a degradation product and not a true member of neomycin complex, has only 1/100 to 1/2 antibacterial activity of neomycin [20] . Commercial preparations of neomycin contain >90% neomycin B.

In vivo. Good protection in experimental murine tuberculosis with s.c. doses of approximately 20-35 mg/kg/da [21] , and in guinea pigs infected with streptomycin-resistant strains of Myco. tuberculosis [22] . On a weight basis, this antibiotic was approximately 1/5 as active as streptomycin in experimental tuberculosis [23] . In mice, single s.c. dosages as low as 5 μg (0.025 mg/kg) gave high protection against M. pyogenes var. aureus, and 0.5-1.0 mg/kg was effective in infections with Salmonella typhosa and S. schottmuelleri [1, 24] . Low doses also suppressed experimental mouse infections with Pr. vulgaris, S. choleraesuis, S. typhimurium, Klebsiella pneumoniae, and H. influenzae [12, 14, 25] . High activity in mice infected with Vibrio comma, Past. multocida, B. anthracis and in chicks with S. gallinarum [26, 35] . In mice with experimental bubonic and pneumonic plague (Past. pestis), neomycin was the most effective of 8 antibiotics tested [27]. Active against S. pullorum and H. pertussis in embryonated eggs [1, 28] . Little or no activity in experimental infections with D. pneumoniae, Str. pyogenes, Listeria monocytogenes, Erysipelothrix rhusiopathiae [14, 25, 26] . Inactive in Borrelia anserina infection (spirochetosis) in chicks [29] , Plasmodium gallinaceum in canaries, and Pl. berghei in mice [30] . No effect in experimental infections with Leishmania donovani, Trypanosoma brucei and T. cruzi [31, 49] . Showed an adverse effect

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/1/ c, 1 water. /2/ 0.02 N NaOH. /3/ 0.2 N H_2SO_4 and 0.2 N HCl. /4/ Water. /5/ c, 0.5 water. /6/ 0.2 N H_2SO_4.

on pinworm infestation in mice; following daily oral dose of 50 mg/kg, mice harbored nearly twice as many worms (Aspiculuris tetraptera) as untreated controls; a similar effect observed with dihydrostreptomycin and chloramphenicol.[32] However, another report indicates neomycin had suppressive effect on mouse oxyurid (Syphacia obvelata) after 500 mg/kg doses [58] . Some activity against experimental rickettsialpox and amebiasis [15] .

CLINICAL Neomycin sulfate has established clinical usefulness as intestinal antiseptic when administered orally prior to bowel surgery. In general, doses of 1 g are administered every 4 hours for 1-3 days. In view of the damage to the kidneys and 8th cranial nerve following systemic use, parenteral administration and prolonged oral medication have not been recommended [8, 33, 34, 40] . Oral doses of approximately 50 mg/kg/da of value in bacillary dysentery, amebiasis, and in epidemic infantile diarrhea [12, 36, 37, 41] . Topical application (solutions containing 5 mg/ml of antibiotic in ointment base) has given favorable results in a variety of infections of the skin [38, 39] and in ocular infections [42] , singly or in combination with other antibiotics. Combination with hydrocortisone in suspension was effective in external otitis [48] . Instillation of solution has given favorable clinical response in cervicitis and vaginitis caused by Proteus spp [43] , and in non-gonococcal urethritis [44] . Patients with peritonitis were successfully treated with daily doses of 1-2 g for 1-3 days, administered by the intraperitoneal route without toxic effects [45] . In tuberculosis, beneficial results were observed, but the attendant nephrotoxicity and ototoxicity, following prolonged parenteral administration, limits its usefulness in the therapy of this disease [12] [36] .

Urinary tract infections responded to intramuscular therapy with 0.5-1.0 g daily for periods up to 5 days [69] . Aerosol treatment with dosages of 42-53 mg of neomycin base/kg/da for one week was beneficial in certain cases of pulmonary complications associated with cystic fibrosis of the pancreas in children [70] . The antibiotic had no therapeutic value in amebic dysentery [71] . In experimental chancroid in human volunteers, induced by intradermal injection of cultures of Hemophilus ducreyi, topical application of 0.5% neomycin sulfate failed to prevent development of infected lesions, in contrast to chloramphenicol and erythromycin which were effective [72] . Daily oral doses of 12 g reduced the elevated blood ammonia levels and prevented coma in patients with hepatic cirrhosis; this effect was attributed to alterations in the intestinal bacterial flora.[73]

VETERINARY Preliminary trials indicated value in bovine mastitis caused by Str. agalactiae, M. pyogenes, Pseudomonas spp, and coliform organisms, following infusion of 0.5 g into each infected udder quarter [12] . A variety of gastrointestinal infections in domestic animals respond to oral therapy [68] . Highly effective in calf scours caused by Salmonella dublin when administered orally in doses of 0.5-1.0 g/da for 7 days [46] . Oral therapy with doses of 0.5 g was effective in calves with enteritis presumably caused by Paracolobactrum sp [74] . Chronic cellulitis and streptococcal septicemia in dogs successfully treated with daily intramuscular doses of 5 mg/lb body weight [75] . Topical application with solutions or ointment gave favorable results in a wide variety of skin and ocular infections of domestic animals [47, 68] . Topical therapy of value in foot-rot in cattle and sheep [67] . The antibiotic powder, topically applied, is a useful adjunct in a variety of veterinary surgical procedures [76] .

ACUTE TOXICITY LD_{50} in mice, 15-53 mg/kg, i.v.; 116-133 mg/kg, i.p.; 265-353 mg/kg, s.c.; >2880 mg/kg, oral. S.c. LD_{50} of neomycin B, 220 mg/kg; neomycin C, 290 mg/kg. Rats tolerated higher doses.[1, 12] Preliminary results in experimental animals suggest that the pantothenate of neomycin is less toxic (with particular reference to ototoxicity) than the sulfate [77] .

In vitro. Low toxicity in tissue cultures; 4.1-6.2 mg/ml required to inhibit outgrowths of skin tissue and 250-500 mg/ml for spleen tissue [50] . When tested by roller tube tissue culture method, concentrations as high as 20 mg/ml were non-toxic to human skin explants [78] .

CHRONIC TOXICITY Mice tolerated 15-30 mg/kg/da, s.c., in divided doses for 30 days. In dogs, s.c. doses of 33-66 mg/kg/da induced renal tubular degeneration and damage to glomeruli. Daily oral doses of 100 mg/kg were well tolerated in dogs.[12]

In man, ototoxicity and nephrotoxicity, following parenteral administration [12, 33, 36, 51, 52] , precludes general systemic use in infections. Total oral doses of 6-10 g, over periods of 1-3 days, were well tolerated [33, 53] . Continued topical use of dermatological preparations is associated with a relatively low index of sensitization, in contrast to penicillin, streptomycin, and the sulfonamides [79] .

RESISTANCE A high degree of resistance could be developed in vitro only in short steps; this pattern resembles that of penicillin rather than streptomycin. No appreciable cross resistance between neomycin and streptomycin or other antibiotics.[2, 55, 56, 59] Some cross resistance, in varying but not marked degrees, between neomycin and streptomycin has been described. Bacteria, rendered resistant by repeated subculture, in the presence of neomycin display no increased resistance to chloramphenicol or the tetracyclines, but may become more resistant to streptomycin than the original strain. This cross resistance is more effectively induced by neomycin than by streptomycin.[80-82]

ABSORPTION AND EXCRETION Very limited absorption after oral administration. In dogs, peak blood levels of 1.0-2.2 μg/ml noted within 1 hour after oral administration of various dosages 3 times daily for 3 days, with a total urinary excretion of approximately 3-8%. In mice, 30 mg/kg oral doses produced no appreciable blood or urine concentrations. Following i.m. doses of 6.5 mg/kg every 6 hours for 8 days, substantial blood levels were continuously maintained throughout this period.[12]

In man, following oral administration, the small fraction absorbed is rapidly excreted in the urine, with the remainder eliminated unchanged in the feces [33] . A single i.m. injection of 1.2 mg/kg produced blood concentration of 4-5 μg/ml, maintained between 1-4 hours after administration, and urine levels of 72 μg/ml in 2 hours [54] .

212. NEOMYCINS (Concluded)

MODE OF ACTION Primarily bactericidal in action; bactericidal concentrations approximate the bacteriostatic titers, e.g., lethal to broth culture of E. coli within 4 hours.[57, 59] In vitro antimicrobial activity antagonized by nucleic acids [12] , and by a heat-stable substance present in culture filtrates of Ps. aeruginosa [60] .

MISCELLANEOUS As compared with certain other antibiotics, neomycin is of little value as a food supplement for the growth stimulation of domestic animals [61] . Topical application of cream or lotion, containing 3.5 mg neomycin per g of vehicle, to the axilla in man was effective in controlling the odor from aprocrine sweat [83] . The antibiotic failed to increase the resistance of wheat seedlings to infection with Xanthomonas translucens [84] . The median lethal dose, by injection, in the German cockroach (Blattella germanica) was 27-60 μg [85] . Concentrations of 10 μg neomycin sulfate, in combination with 20 units of nystatin per ml, have been recommended for routine prevention of bacterial and fungal contaminations in tissue cultures [86] .

213. NEONOCARDIN

SOURCE Nocardia kuroishi, n. sp [2] .

FORM AND COLOR Crude HCl: grayish-white [1] .

SOLUBILITY s. water, methanol, ethanol; sl. s. amyl alcohol, benzene; i. ether, petroleum ether, toluene, amyl acetate, xylene.[1]

STABILITY Thermostable[1] [1] .

OTHER REACTIONS Slow diffusion through agar [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Escherichia coli, Bacillus anthracis. Low activity against B. subtilis, Pseudomonas aeruginosa.[1]

TOXICITY LD_0 of crude preparations in mice, 100 mg/kg, i.p. [1] .

214. NETROPSIN
(IA 887)

SOURCE Streptomyces netropsis [1] ; S. chromogenus, n. sp, resembling S. netropsis [6] .

NATURE Tetra-acidic base [1] ; diacidic base [7] .

MOLECULAR FORMULA AND WEIGHT $C_{32}H_{48}O_4N_{18}$ (proposed) [1] ; $C_{18}H_{26}N_{10}O_3$ [7] . Sulfate: 945 (calc.) [2] .

CRYSTAL FORM AND COLOR HCl: long, thin, colorless hydrated prisms [1] . Sulfate: long, colorless needles [2] . Picrate: sheaves of yellow needles [2, 6] .

MELTING POINT (°C) HCl: 167-172 (d.) [1, 6] . Sulfate: 224-225 [2] . Picrate: 232 (d.) [7] , 205 (d., uncorr.) [6] .

OPTICAL ACTIVITY Inactive [1] .

UV ABSORPTION MAXIMA 238, 295 mμ [2] ; 236, 297 mμ [6, 7] .

SOLUBILITY s. water; i. organic solvents.[2]

STABILITY Thermostable at acid pH; alkali labile.[2, 6]

OTHER REACTIONS Positive Sakaguchi, Ehrlich; negative ninhydrin, biuret, Tollens, Fehling, fuchsin-aldehyde, murexide, $FeCl_3$, aminoantipyrine, 2, 4-dinitrophenylhydrazine; anhydrous HCl hygroscopic.[1, 6] Converted by hydrolysis to 1 mole each of ammonia, guanidinoacetic acid and netropsinine ($C_{15}H_{20}N_6O_3$) [7] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, M. pyogenes var. albus, B. subtilis, Mycobacterium ranae, Salmonella typhosa, S. pullorum, S. schottmuelleri, Klebsiella pneumoniae, Aerobacter aerogenes, Shigella paradysenteriae, 5-10 μg/ml. Pseudomonas aeruginosa, Proteus spp not sensitive. [1, 3] Protozoa: Trichomonas vaginalis inhibited by 12.5 μg/ml [4] . Phagicidal to a number of bacteriophages [8] .

In vivo. Slight protection (prolonged survival time) in mice infected with S. typhosa and Ps. aeruginosa [1] . Showed antiviral activity in mice infected intracerebrally with "WR" strain of vaccinia virus [5] . Daily i.p. doses of 30 mg/kg for 5 days protected mice against vaccinia virus introduced by intranasal or intracerebral routes [9] .

/1/ No loss at 100°C for 10-30 minutes; 90% loss for 60 minutes.

214. NETROPSIN (Concluded)

No activity in mice against viruses of feline pneumonitis, influenza, poliomyelitis, or western equine encephalitis [5] . Seven daily i.p. doses of 25 mg/kg inhibited Mecca lymphosarcoma in mice [10] . Little or no suppressive effect on a variety of other experimental neoplasms [11] . Had insecticidal properties; active against clothes moth larvae and black carpet beetle.[1]

TOXICITY LD_{50} in mice, 17 mg/kg, i.v.; 70 mg/kg, s.c.; >300 mg/kg, oral.[1] LD_{50} in chick embryo, 0.03 mg per egg injected into yolk sac of 4-day old embryo [12] .

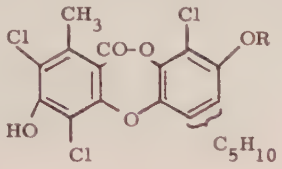
215. NIDULIN and NOR-NIDULIN

Nor-nidulin formerly called ustin.

SOURCE Aspergillus nidulans [1] .

MOLECULAR FORMULA AND WEIGHT Nidulin: $C_{20}H_{17}O_5Cl_3$; 463 (micro-Rast); 443.7 (calc.).[4, 5]
Nor-nidulin: $C_{19}H_{15}O_5Cl_3$; 214 (neut. equiv.).[3, 5]

STRUCTURE



Nidulin: R = CH_3

Nor-nidulin: R = H

[4]

CRYSTAL FORM AND COLOR Nidulin: colorless rhombs[1]; slender shining rods[2].[4, 5]
Nor-nidulin: heavy square plates[3]; rosettes of fine needles[4]; hexagonal plates or prisms[2].[2, 5]

MELTING POINT (°C) Nidulin: 180 [4, 5] .
Nor-nidulin: 185-187[3]; 214-216[4].[2, 5]

OPTICAL ACTIVITY Inactive[5] [4, 5] .

UV ABSORPTION MAXIMUM Nidulin: 267 mμ[6].
Nor-nidulin: 266 mμ[6]. [5]

SOLUBILITY s. aqueous NaOH[7], $NaHCO_3$, chloroform; sl. s. 95% ethanol, benzene, petroleum ether; i. water.[4, 5]

STABILITY Thermostable; inactivated by heat in alkali.[1]

OTHER REACTIONS Monomethyl, dimethyl and acetyl derivatives; increased activity at lower pH; decreased activity by serum albumin, lipids, components of complex media.[3] Nidulin is monomethyl ester of nor-nidulin [4] . Nidulin isolated from mycelium, nor-nidulin from culture fluids. Nidulin: negative $FeCl_3$, Fehling, aqueous methanolic 2, 4-dinitrophenylhydrazine sulfate.[5]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium tuberculosis [1, 4] .

BIOLOGICAL ACTIVITY In vitro. Nidulin: Inhibits Myco. tuberculosis at 1:5000-1:10, 000; little or no activity against other bacteria. Fungi: Trichophyton tonsurans, Microsporum audouini sensitive to 1:1000.[4]

Nor-nidulin: Inhibits Micrococcus pyogenes var. aureus, Streptococcus sp at 1:500, 000; Myco. tuberculosis, 1:200, 000-1:500, 000; Myco. ranae, 1:300, 000.[1-3]

TOXICITY Mice tolerated 300-400 mg/kg i.p. doses of crude nor-nidulin [1] .

216. NIGERICIN

SOURCE Streptomyces sp related to S. violaceoniger [1] .

NATURE Monobasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_{39}H_{69}O_{11}$; 728 (found); 713.55 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless needles[8] [1] .

MELTING POINT (°C) 246-254 (uncorr.)[8] [1] .

/1/ From ethanol. /2/ From petroleum ether. /3/ Fraction I. /4/ Fraction II. /5/ c, 4 chloroform.
/6/ Inflection at 323 mμ. /7/ Crude nidulin soluble in aqueous NaOH, crystalline nidulin insoluble. /8/ Sodium salt.

SOLUBILITY s. most organic solvents; sl. s. water.[1]

STABILITY Thermostable at neutral pH [1] .

QUANTITATIVE DETERMINATION Microbiological: Sarcina lutea [1] .

BIOLOGICAL ACTIVITY Active against Gram-positive bacteria, including mycobacteria and certain fungi. In vitro. Inhibits (μg/ml) Bacillus subtilis, B. mycoides, Micrococcus pyogenes var. aureus, M. flavus, S. lutea, Mycobacterium ranae, 0.12-0.5; Myco. smegmatis, Mycobacterium sp, 4.0; Brucella bronchiseptica, Escherichia coli, Pseudomonas aeruginosa, Proteus vulgaris, 64. Candida albicans inhibited by 2 μg/ml; Trichophyton mentagrophytes by 16.[1] High activity in concentration of 0.2 ppm, in accelerating death of spores of Clostridium botulinum, suggests its usefulness as food preservative [2] .

TOXICITY LD_{50} in mice, 2.5 mg/kg, i.p. [1] .

217. NISINS

SOURCE Streptococcus cremoris [4] .

NATURE Polypeptide or low molecular weight protein [2] .

CRYSTAL FORM AND COLOR Almost white needles [2] .

UV ABSORPTION MAXIMUM 275 mμ [3] .

SOLUBILITY s. ethanol, formamide, acids; s. but activity destroyed in glacial acetic acid, benzyl alcohol, other organic solvents.[2]

STABILITY Thermostable at acid pH, not at alkaline [2] .

OTHER REACTIONS Dialyze; precipitate from solution at neutrality; negative Ehrlich.

Nisin A, B, C: Contain leucine and/or isoleucine, valine, alanine, glycine, proline, aspartic acid, histidine, lysine, methionine, lanthionine, and a structural isomer of cystathionine.

D: Contains glutamic acid, no valine or methionine; resemblance to subtilin; S-containing amino acids may also be present in cinnamycin.[1, 3]

QUANTITATIVE DETERMINATION Microbiological: Streptococcus agalactiae, Mycobacterium phlei [1, 2] .

BIOLOGICAL ACTIVITY In vitro. Crude nisin preparations inhibited (units/ml) hemolytic streptococci, 0.25-4.0; Diplococcus pneumoniae, 0.25-100; Clostridium spp, 0.25-80.0; Neisseria spp, 2-50; Corynebacterium spp, 4-120; Erysipelothrix rhusiopathiae, 2; Micrococcus pyogenes var. aureus, 100; Myco. tuberculosis, 100-500; Actinomyces spp, 1-10.[6] Fractions A, B, C, D displayed activity similar to crude nisin in inhibition of Myco. tuberculosis in dilution of 1:100,000-1:800,000 [1] . Nisin failed to inhibit intracellular Myco. tuberculosis within rabbit macrophages in vitro in concentration of 50 μg/ml; streptomycin and other antitubercular agents were effective in lower concentration under same test conditions.[8] Inhibited growth of anaerobic spore formers responsible for spoilage of European fondu cheeses at 50-100 units/g cheese [11, 13] , and prevented growth of Cl. botulinum at 5 ppm [12] , suggesting value as food preservative.

In vivo. Protection afforded in mice against infections with Str. agalactiae [5] , Str. pyogenes, M. pyogenes var. aureus [1, 7] , and Cl. septicum [6] . No activity in experimental mouse tuberculosis [7] , although preliminary experiments had suggested slight activity in guinea pigs with same infection [6] .

VETERINARY Intramammary instillation of 2.5-5 million units per quarter in bovine udder was of some value in mastitis caused by Str. agalactiae. During treatment a depression in milk yield was noted.[9, 10]

PHARMACOLOGY LD_0 in mice, 400 mg/kg, i.v. Repeated daily doses of 50 mg/kg, i.v., or 250 mg/kg, s.c., were well tolerated in mice and guinea pigs. Following i.m. doses of 200,000 units in rabbits, blood concentration of 4 units/ml in 6 hours was noted, with high levels excreted in the urine [6] ; in mice, antibiotic detectable in blood, tissues and urine several hours after i.v. injection of 50 mg/kg [1] . Substantial blood concentrations noted in rabbits after s.c. injection of nisin at 12-hour intervals [5] .

218. NITROSPORIN

SOURCE Streptomyces nitrosporeus [1] .

NATURE Basic [1] .

MOLECULAR FORMULA $C_{20}H_{26}N_2O_6$ [1] .

218. NITROSPORIN (Concluded)

CRYSTAL FORM AND COLOR White crystals [1] .

MELTING POINT (°C) 130-140 (d.)[1] [1] .

UV ABSORPTION MAXIMA 250, 320 mμ [1] .

SOLUBILITY s. alcohol, ethyl acetate, acid water; sl.s. ether, benzene, ethylene dichloride; i. water [1] .

OTHER REACTIONS White crystals turn light-brown on exposure to air [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, 0.2-0.4; Bacillus subtilis, 0.2; Diplococcus pneumoniae, Streptococcus pyogenes, 0.1-0.4; Escherichia coli, 25; Salmonella typhosa, 12.5; S. paratyphi, 100; Shigella dysenteriae, Hemophilus pertussis, 50; Proteus vulgaris, B. anthracis, Corynebacterium diphtheriae, Mycobacterium spp, S. schottmuelleri, >100. No activity against fungi.[1]

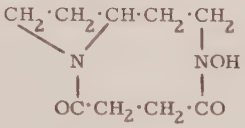
TOXICITY LD_{50} in mice, approximately 16 mg/kg, i.v. [1] .

219. NOCARDAMIN

SOURCE Nocardia sp related to N. flavescens [1] .

MOLECULAR FORMULA $C_9H_{14}O_3N_2$ [1, 2] .

STRUCTURE



[2]

CRYSTAL FORM Needles in clusters [1, 2] .

MELTING POINT (°C) 183-184 (corr.) [1, 2] .

OPTICAL ACTIVITY Inactive [1, 2] .

OTHER REACTIONS Red-brown with $FeCl_3$; yellow, then Ag mirror with ammoniacal Ag solution; green with copper chloride; reduced Fehling.[1]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium phlei [1] .

BIOLOGICAL ACTIVITY In vitro. Bactericidal to Myco. phlei in dilution of 1:1000. No activity against other bacteria at 1:1000 dilution: Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Escherichia coli, Salmonella typhosa, Shigella dysenteriae, and fungi.[1, 2] In vitro activity reduced by serum [1] .

220. NOCARDIANIN

SOURCE Nocardia sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{65-67}H_{96-104}O_{15}N_{18}$; 1375 (found).[1]

CRYSTAL FORM AND COLOR Red prisms [1] .

MELTING POINT (°C) 228-235 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -223^{\circ}$[2] [1] .

UV ABSORPTION MAXIMUM 440 mμ [1] .

SOLUBILITY s. chloroform, glacial acetic acid, pyridine, acetone, methanol, dilute acids; sl. s. ether, water; i. petroleum ether, carbon disulfide, carbon tetrachloride.[1]

OTHER REACTIONS Negative xanthine, Liebermann, Millon, Duke, Schiff, Ehrlich, fluorescein chloride, biuret, hydroxamic, ninhydrin [1] .

/1/ Browns at 115-120°C. /2/ c, 0.3 methanol.

220. NOCARDIANIN (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Gram-positive bacteria. No activity against mycobacteria or Gram-negatives.[1]

221. NOCARDORUBIN

SOURCE Nocardia sp [1] .

NATURE Pigment [1] .

STRUCTURE Possible quinoid structure [1] .

MELTING POINT (°C) Blackens at 180; no melting at 250.[1]

SOLUBILITY Alkaline form: sl. s. dioxane, ethyl acetate, chloroform, propylene glycol; i. most organic solvents, water. Acid form: s. most organic solvents, water [1] .

STABILITY Stable at neutral and alkaline pH; unstable at pH 2.0.[1]

OTHER REACTIONS Red in alkali, yellow in acid; negative Fehling; not decolorized by Zn dust; activity unaffected by NaCl, dextrose.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209-P [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Corynebacterium diphtheriae, 0.001; Bacillus subtilis, 0.05-0.5; B. mesentericus, 0.1; Diplococcus pneumoniae, 0.2-0.5; M. pyogenes var. aureus, M. pyogenes var. albus, 0.5; Streptococcus pyogenes, Str. viridans, 1.0; Mycobacterium avium, 1.2; Myco. phlei, 1.6; Myco. tuberculosis var. hominis, 1-5; Str. faecalis, Hemophilus pertussis, 5; Escherichia coli, Proteus vulgaris, Shigella dysenteriae, Salmonella typhosa, S. paratyphi, S. schottmuelleri, 10-20. Also inhibits Streptomyces griseus, 5; Aspergillus niger, 20; Saccharomyces saké, >100. Micrococci and mycobacteria did not readily develop resistance in vitro.[1]
In vivo. Single s.c. doses of 5 mg protected mice against D. pneumoniae [1] .

TOXICITY LD_0 of crude extracts in mice, 154 mg/kg, i.p. [1] .

222. NOFORMICIN

SOURCE Nocardia formica [1] .

MOLECULAR FORMULA Cryst. sulfate: $C_{17}H_{34}N_{10}\text{-}O_5(SO_4)_2$ [1] .

MELTING POINT (°C) HCl: 265 (d.)[1] [1] .

SOLUBILITY s. water [1] .

STABILITY Stable in solution up to pH 8 [1] .

OTHER REACTIONS Dialyzable; ammonia and glutamic acid are among the hydrolysis products; two other ninhydrin-active, non-amino acid materials are present; approximately 70% of the N remains unaccounted for; no phenolic groups; non-reducing.[1]

QUANTITATIVE DETERMINATION Microbiological: Increase in survival time of mice infected intranasally with swine influenza virus [1] .

BIOLOGICAL ACTIVITY In vitro. Slight activity against Diplococcus pneumoniae, Corynebacterium pseudodiphtheriticum. Protozoa: Trichomonas foetus, T. vaginalis inhibited by 1:40-1:80 dilution. Failed to inactivate viruses in vitro.[1]
In vivo. Administration by i.v., oral, or s.c. route protected mice infected intranasally with viruses of influenza A and B and swine influenza. No activity against Columbia-SK encephalomyelitis virus in mice, hog cholera in swine, hepatitis in dogs, enteritis virus in mink, or Newcastle disease virus in mice or chickens. Suppressed mumps virus and Newcastle disease virus in embryonated eggs.[1-3]

TOXICITY Mice tolerated 10 mg/kg, s.c., in single doses, multiple s.c. or i.v. daily doses of 5 mg/kg, or oral doses of 12.5 mg/kg. Mice receiving these doses developed alopecia.[2] Concentrations of 100 μg/ml were toxic to tobacco plant [4] .

/1/ 99.8% pure.

222. NOFORMICIN (Concluded)

PHYTOPATHOLOGY No in vitro inactivation of tobacco mosaic virus or southern bean mosaic virus when exposed to 250 ppm noformicin HCl for 24 hours at 28°C, or 81 hours at 6°C. In systemic infections, antibiotics suppressed development of lesions by southern bean mosaic virus in intact Pinto bean plant, and by tobacco mosaic virus in tobacco plant, following spray of 50-220 ppm pure antibiotic at 1, 24 and 48 hours after inoculation with virus suspension. Antibiotic absorbed by roots; was translocated from base of leaf toward tip and in the reverse direction to a lesser extent. Antiviral activity similar to, but not as lasting as, thiouracil.[5]

223. NOTATIN
(Penatin, Penicillin B)

SOURCE Penicillium notatum and other Penicillium spp [1, 4, 5] .

NATURE Flavoprotein, glucose-oxidase enzyme [3, 4, 6, 7] .

MOLECULAR WEIGHT 152,000 (ultracentrifuge) [8] .

FORM AND COLOR Yellow- or buff-colored powder [1, 5, 7] .

OPTICAL ACTIVITY $[\alpha]_D^{22} = -4.8^{\circ}$[1] [4] .

ABSORPTION MAXIMA 270-280, 375-380, 450-460 mμ [4] .

SOLUBILITY s. water; i. organic solvents [1, 2, 5] .

STABILITY Heat labile; unstable except at pH 2-8 [1, 2, 4, 5] .

OTHER REACTIONS Non-dialyzable; positive protein reactions; precipitated by tannic, tungstic, phosphotungstic, phosphomolybdic, trichloroacetic, flavianic, rufianic acids; green fluorescence with acetic acid; inactivated by alcohol; by nature requires dextrose to be effective.[1, 2, 4, 5]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Escherichia coli [2, 4, 5] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (in dilution x 10^6) Streptococcus pyogenes, Streptococcus spp, Salmonella typhosa, Proteus vulgaris, Vibrio comma, 10-1000; Neisseria catarrhalis, Sarcina lutea, Gaffkya tetragena, 250; Diplococcus pneumoniae, 12.5-100; M. pyogenes var. aureus, 42-125; Salmonella paratyphi, 25-100; Shigella paradysenteriae, 100; Brucella abortus, Br. melitensis, Bacillus anthracis, B. subtilis, B. mycoides, Corynebacterium diphtheriae, Aerobacter aerogenes, Clostridum histolyticum, Salmonella enteritidis, S. schottmuelleri, S. typhimurium, 10-50; Sh. sonnei, E. coli, 1-10; Klebsiella pneumoniae, 0.1-1.0.[4, 5, 9]

In vivo. No activity in mice infected with M. pyogenes var. aureus, Str. pyogenes or Salmonella sp [10] .

TOXICITY LD$_{50}$ in mice, 3 mg/kg, i.p.; 4.5 mg, s.c.[5] Rabbits tolerated oral doses of 300 mg/kg. In rats, antibiotic produced methemoglobinemia; no marked chronic toxicity.[10]

224. NOVOBIOCIN
(Antibiotic PA-93, Streptonivicin)

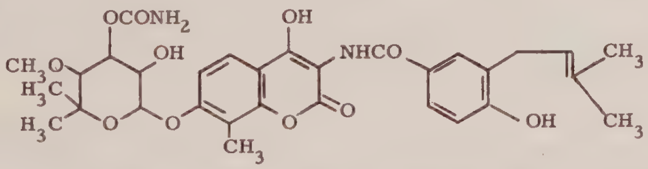
Trademarks for novobiocin are Albamycin (The Upjohn Company), Cathomycin (Merck & Co., Inc.)
and Cardelmycin (Chas. Pfizer & Co., Inc.).[2]

SOURCE Streptomyces niveus [1, 2] , and S. spheroides [3, 4] .

NATURE Dibasic acid [1, 3, 5] .

MOLECULAR FORMULA AND WEIGHT $C_{31}H_{36}N_2O_{11}$ [6] ; 592 ± 25 (ebull.); 610 (Rast); 618 (X ray).[1, 3, 5]

STRUCTURE



[7]

CRYSTAL FORM AND COLOR Pale yellow; 2 crystalline forms.[1, 3-5]

MELTING POINT (°C) 152-154, 152-156 (d.), and 170-172, 174-178 (d.) [1, 3-5, 8] .

/1/ c, 0.012 water. /2/ Cathocin was formerly a trademark of Merck & Co., Inc., for novobiocin, but both this name and streptonivicin have been eliminated.

OPTICAL ACTIVITY $[\alpha]_D^{25} = -27^{\circ}$[1] [3, 4], -44°[2] [3, 4]; $[\alpha]_D^{24} = -63^{\circ}$[3] [1, 5]; $[\alpha]_D^{28} = -34.0^{\circ}$[2] [8]; $[\alpha]_D^{26} = -35.2^{\circ}$[2] [8].

UV ABSORPTION MAXIMA 304 mμ in pH 7 phosphate buffer; 248, 308 mμ in 0.01N ethanolic phosphate buffer pH 7.5; 307 mμ in 0.1N NaOH; 311 mμ in 0.01N ethanolic KOH; 324 mμ in 0.1 HCl-methanol; 334 mμ in 0.01N ethanolic H_2SO_4. 238, 250 (shoulder), 290 (shoulder), 304 mμ in 1% phosphate buffer pH 6; 290 (shoulder), 326 mμ in 0.1 N HCl and 95% methanol; 230 (shoulder), 307 mμ in 0.1 N NaOH.[1, 3, 5, 8]

SOLUBILITY s. in aqueous solution above pH 7.5; i. below. Acid form: s. acetone, ethyl acetate, amyl acetate, methanol, ethanol, pyridine.[5, 8]

STABILITY Dry material of both forms stable at 24°C in absence of light; dilute aqueous solution stable at pH 2 at 24°C; half-life, 60 days at pH 7-10.[5]

OTHER REACTIONS pK'a 4.3 and 9.1 in water; catalytic hydrogenation with Raney nickel yields dihydrostreptonivicin, MP 163-165°C; hydrolysis with 4N HCl in 60% ethanol yields an optically inactive acid. Infrared of Form I (MP 174°): 3500, 3445, 3395, 1744, 1738, 1694, 1642, 1607, 1542, 1500, 1374, 1360, 1320, 1294, 1280, 1252, 1235, 1219, 1162, 1138, 1124, 1103, 1091, 1080, 1062, 1029, 1000, 969, 930, 904, 879, 846, 800, 789, 770, 755, 739, 716 (recip. cm); Form II (MP 152°): 3480, 3360, 3280, 1715, 1690, 1635, 1610, 1586, 1534, 1507, 1374, 1344, 1315, 1293, 1259, 1186, 1157, 1121, 1084, 1064, 1022, 998, 972, 934, 919, 837, 818, 809, 789, 781, 761, 753, 741 (recip. cm); both crystalline forms are isotropic with a mean refractive index of 1.595 ± 0.003.[1, 5, 8]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus; Klebsiella pneumoniae[4]. [2, 9] Streptothricin-resistant strain of M. pyogenes var. aureus [32]. Colorimetric [33].

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) M. pyogenes var. aureus (including strains resistant to penicillin, streptomycin, erythromycin, chloramphenicol, and the tetracycline antibiotics) at 0.02-25; Corynebacterium diphtheriae, 0.04-0.78; Hemophilus pertussis, 0.06; Neisseria meningitidis, 0.09-3.1; M. pyogenes var. albus, Sarcina lutea, 0.19; Diplococcus pneumoniae, 0.19-12.5; Streptococcus agalactiae, C. renale, H. influenzae, 0.2-0.8; N. gonorrheae, 0.4-6.3; Str. pyogenes, 0.78-200; Pasteurella multocida, 0.78-12.5; Str. viridans, 0.78-50; C. pseudotuberculosis, Erysipelothrix rhusiopathiae, 0.8-25; Proteus vulgaris, 1.0->400; Leuconostoc mesenteroides, L. citrovorum, 2.5; Mycobacterium tuberculosis var. hominis, 2.5-62; X. pruni, 3.0; Str. uberis, 6.2; K. pneumoniae, Pr. rettgeri, 6.2->200; Aerobacter aerogenes, 12.5->400; Clostridium novyi, 12.5-25; Salmonella typhosa, 12.5-1000; S. paratyphi, S. schottmuelleri, Shigella dysenteriae, Pseudomonas aeruginosa, 12.5->1000; Cl. sporogenes, Serratia marcescens, 25; Pr. mirabilis, 25-100; Brucella abortus, 31.2; Proteus spp, 12.5-400; Corynebacterium pseudodiphtheriticum, 50; Escherichia coli, Pr. morgani, 50->400; Salmonella pullorum, 50->1000; S. typhimurium, Erwinia amylovora, 100; Sh. sonnei, 100->100. Nocardia asteroides sensitive to 10-100 μg/ml. Blastomyces dermatitidis inhibited by 15 μg/ml; Monosporium apiospermum, 100-1000. Trichophyton mentagrophytes, Microsporum audouini, Aspergillus niger, Cryptococcus neoformans, and Candida albicans not sensitive to 100 μg/ml. Trichomonas vaginalis inhibited by 125 μg/ml.[2, 10, 11, 17, 18, 22] In vitro activity is reduced in presence of serum [12-14].

In vivo. Single mouse doses of 0.3-1.8 mg, s.c., protected 50% of mice against infection with Micrococcus pyogenes var. aureus, D. pneumoniae, Proteus sp, Pr. vulgaris, and Past. multocida. The median effective dose in Str. pyogenes infection was 7.0 mg/mouse. Dosages of this order by oral or other routes gave comparable results. Dietary levels of 100 mg/kg controlled an experimental chronic M. pyogenes var. aureus infection. Seven i.p. doses of 1.5 mg protected mice against intranasal infection with H. pertussis. No in vivo activity demonstrated against K. pneumoniae, Escherichia coli, Ps. aeruginosa, S. typhosa, S. schottmuelleri, Shigella dysenteriae and Myco. tuberculosis in mice. No protection afforded against murine infection with Rickettsia mooseri, Columbia-SK encephalomyelitis virus, or with Trypanosoma brucei and Trichomonas foetus. In chick embryos there was no demonstrable activity against influenza B (Lee strain) or Newcastle disease virus. Activity against Plasmodium gallinaceum in chicks was approximately 1/10 that of quinine sulfate.[10, 11, 17, 19]

CLINICAL Generally good clinical responses have been reported in a variety of infections caused by susceptible bacteria (including pneumococcal and Friedländer pneumonia, acute pharyngitis, sinusitis, otitis media, panophthalmitis, urinary tract infections, scarlet fever, cutaneous anthrax, breast abscess, acute tracheobronchitis, bacteremia, osteomyelitis) and in wound infections. Oral therapy with 1.5-2.0 g per day in divided doses in adults, or 5 mg/kg every 6 hours in infants and children, has been employed. Intravenous and intramuscular therapy has also been described.[16, 26-30] Successfully used in conjunction with surgery in cases of soft tissue infection [25]. Oral therapy gave excellent results in pyodermic infections caused by M. pyogenes var. aureus, and Str. pyogenes [15]. In preliminary trials in amebiasis, oral doses of 1.5 g daily for 10 days gave indifferent results [20].

TOXICITY LD_{50} in mice, 407 mg/kg, i.v.; 262-300 mg/kg, i.p.; 962->1000 mg/kg, oral. LD_{50} in guinea pigs, 11.5 mg/kg, i.p.; 27.8 mg/kg, s.c.[21] Poor weight gains in guinea pigs treated with daily s.c. doses of 5-12.5 mg/kg for 3 weeks. In rats, 385 mg/kg/da in the diet for 8 weeks were well tolerated, with no evidence of pathologic changes. The antibiotic was moderately irritating to rabbit skeletal muscle. In dogs, daily i.v. doses of 50-100 mg/kg for 5 days produced no evidence of systemic toxicity; 300 mg/kg for 2-4 days induced rapid emesis and prostration -- at necropsy these animals showed severe hepatic and renal changes, gastrointestinal hemorrhages and severe vascular irritation. Pharmacodynamic studies in barbital-anesthetized dogs disclosed no alarming properties.[21]

/1/ c, 1 in 1 N NaOH. /2/ c, 1 in pyridine. /3/ c, 1 in ethanol. /4/ PCI 602, ATCC 10031.

224. NOVOBIOCIN (Concluded)

In man, daily oral doses of 1.5-2.0 g, 500 mg intravenously at 12-hour intervals, or 250 mg intramuscularly, were well tolerated. Allergic dermatitis appeared to be a fairly common reaction to the oral doses; other side effects were minimal.[20, 26-30] Drug rash was almost completely absent in a group of 208 adults given 0.5 g twice daily for a total dosage of 10 g over a 12-day period [31] .

RESISTANCE Strains of M. pyogenes var. aureus developed resistance fairly rapidly (13-15 subcultures in antibiotic) in vitro. This development appeared to be intermediate between the rapid one-step pattern characteristic of streptomcyin and the stepwise penicillin-type. Initially the rate was rapid, with a levelling off followed by a stepwise development.[12-14, 17] No cross resistance shown between this antibiotic and penicillin, streptomycin, chloramphenicol, erythromycin, carbomycin, tetracyclines, bacitracin, polymyxin, or spiramycin [10, 22] .

ABSORPTION AND EXCRETION There is a high degree of binding by serum albumin [14, 18] . Unusually high and well-maintained blood levels obtained with peak concentrations in 2-4 hours after oral administration in dogs and man. Oral doses of 40 mg/kg in dogs produced peak levels of 128 μg/ml. Approximately 1/3 of the oral dose was excreted in the feces, with only approximately 1% detected in the urine within 24-48 hours. The antibiotic was widely distributed in the tissues as well as in body fluids. In mice, the serum levels were relatively lower, with highest concentrations within one hour.[9]

In man, single oral doses of 10 mg/kg produced peak serum levels of 57 μg/ml in 2 hours. Initial oral doses of 2.0 g promptly produced high serum levels (126 μg/ml), and subsequent therapy with 500 mg at 12-hour intervals tended to maintain levels in the range of 20 μg/ml or greater. Urinary excretion was quite low and approximated 2.7-3.3% of the administered dose. Distributed in pleural and ascitic fluids and in thyroid tissue; excreted in bile, urine, and feces. No detectable concentrations in cerebrospinal fluid.[9, 13, 14, 19, 23, 24] Following single intramuscular doses of 250 mg, serum levels up to 12.8 μg/ml noted in 1-2 hours and 1.6-6.4 μg/ml in 4 hours [18, 23] .

MODE OF ACTION Bacteriostatic; also significantly bactericidal in vitro. Concentrations of 11.7 μg/ml lethal to D. pneumoniae within 4 hours.[11] A strain of M. pyogenes var. aureus, for which 0.1 μg/ml was bacteriostatic, was rendered non-viable by 1.0 μg/ml in 48 hours, 10 μg/ml in 24 hours, and 100-1000 μg/ml in 7 hours [17] .

225. NUDIC ACIDS

SOURCE Tricholoma nudum [1] .

MOLECULAR FORMULA AND WEIGHT Nudic acid A: $C_{14}H_{20}O_3$ (proposed).
B: $C_8H_4O_3$ (proposed); 135-140 (found); 148 (calc.).[1]

CRYSTAL FORM AND COLOR Nudic acid A: colorless needles or plates.
B: small, colorless needles [1] .

MELTING POINT (°C) Nudic acid A: 123.5 (uncorr.).
B: 150 (darkens, sublimes) [1] .

OPTICAL ACTIVITY Active[1] [1] .

SOLUBILITY s. most organic solvents; sl. s. hot water; i. cold water, hexane, dilute acids.
Nudic acid A: s. sodium carbonate.
B: sl. s. sodium carbonate.[1]

STABILITY Nudic acid A: Thermostable.
B: Thermostable only at acid and neutral pH [1] .

OTHER REACTIONS Negative Fehling, ammoniacal $AgNO_3$, KI; decolorized aqueous $KMnO_4$.
Nudic acid A: Decolorizes Br water; amorphous precipitate with 2, 4-dinitrophenylhydrazine.
B: No decolorization of Br water; no precipitate with 2, 4-dinitrophenylhydrazine; loses activity in pyridine; crystals darken after 2-hour exposure to sunlight.[1]

BIOLOGICAL ACTIVITY In vitro. Nudic acid A: Inhibits Escherichia coli, Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Bacillus anthracis, Salmonella enteritidis, Corynebacterium xerose in dilution of 1:2000-1:8000.
B: More active; inhibits M. pyogenes var. aureus, B. anthracis, Proteus sp, S. typhosa in dilution of 1:8000-1:640, 000.[1]

TOXICITY Nudic acid A: LD_0 in mice, 25 mg/kg, i.v.
B: LD_0, approximately 6.2 mg/kg, i.v.[1]

/1/ Alcohol.

226. NYBOMYCIN

SOURCE Streptomyces sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_8H_7O_2N$; 164 (ebull. in acetic acid); 149 (calc.).[1]

CRYSTAL FORM AND COLOR Small, colorless, thin needles, rods, or rhomboid forms[1] [1] .

MELTING POINT (°C) Darkens at 330 without melting [1] .

UV ABSORPTION MAXIMA 266, 285 mμ[2] [1] .

SOLUBILITY s. concentrated HCl; less s. boiling acetic acid, boiling lower alcohols; sl. s. cold water, alkali, organic solvents.[1]

OTHER REACTIONS Sublimes in vacuo at 250°C without change in UV or loss of biological activity; negative $FeCl_3$, biuret, ninhydrin.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus cereus phage [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Klebsiella pneumoniae, 0.003-0.08; B. subtilis, 0.025-0.25; Mycobacterium smegmatis, 0.2; B. mycoides, 0.8; B. cereus, 2; Escherichia coli, 0.08->50; Micrococcus pyogenes var. aureus, 1.0->50; Pseudomonas aeruginosa, >50. Active against a variety of phages, including those of E. coli, B. subtilis, Salmonella, Shigella, Pseudomonas, Vibrio comma, Streptococcus, Enterococcus, and M. pyogenes var. aureus. [1]

TOXICITY Mice tolerated 250 mg/kg (in peanut oil), i.p. Following this dose, detectable concentrations were observed in the feces within 24 hours and in the urine after 3 days.[1]

227. NYSTATIN

(Fungicidin)

The trademark of E. R. Squibb and Sons, Division of Olin Mathieson Chemical Corp., for nystatin is Mycostatin.

SOURCE Streptomyces noursei [1] .

NATURE Amphoteric [2] .

MOLECULAR FORMULA AND WEIGHT $C_{46}H_{83}NO_{18}$ (proposed); 922, 956 (neut. equiv.); 939 (calc.).[2]

FORM AND COLOR Yellow powder [1] .

MELTING POINT (°C) Gradual decomposition above 160 without melting at 250 [2] .

OPTICAL ACTIVITY $[\alpha]^{25}_D = +10°$[3], +21°[4], +12°[5], -7°[6].[2]

UV ABSORPTION MAXIMA 280, 291, 304, 318 mμ [2] .

SOLUBILITY sl. s. methanol, ethanol, butanol, dioxane; i. water, pyridine, dimethylformamide, glacial acetic acid, 0.05 N methanolic HCl or NaOH.[1, 2]

STABILITY No loss in cold; unstable at pH 2 or 9.[1, 2]

OTHER REACTIONS Negative $FeCl_3$, Millon; positive Molisch, carbazole; decolorizes $KMnO_4$, Br-CCl_4; in concentrated H_2SO_4, color changes from violet to blue to black; strong blue color with $FeCl_3$-$K_3Fe(CN)_6$; no reduction of Fehling or Tollens; slow positive Schiff aldehyde test.[2]

QUANTITATIVE DETERMINATION Microbiological: Cryptococcus neoformans, Candida albicans, Saccharomyces cerevisae [1, 3] .

BIOLOGICAL ACTIVITY In vitro. Active against fungi. Inhibits, in concentrations of 1.25-6.25 μg/ml, Blastomyces brasiliensis, Bl. dermatitidis, Coccidioides immitis, Cryptococcus neoformans, Epidermophyton floccosum, Histoplasma capsulatum, Microsporum audouini, M. canis, Trichophyton mentagrophytes, T. rosaceum and T. rubrum. [1] Strains of Candida albicans and Geotrichum spp inhibited by 1.25-12.5 μg/ml [1, 10] . Concentrations of 575 units/ml (250 μg/ml) inhibited Entamoeba histolytica. Enhancement of amebacidal activity observed when combined with fumagillin, bacitracin, polymyxin, or the tetracyline antibiotics.[16] Antifungal activity enhanced by alcohols; activity depressed by glucose and other sugars, and unsaturated fatty acids.[36, 40]

In vivo. S. c. doses of 25-150 mg/kg protected mice against infections with C. albicans [4, 7] , H. capsulatum [6] , Coccidioides immitis [5, 8] , Cryptococcus neoformans [8] , and Sporotrichum schenckii [8] . In mice infected

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/1/ Depending on solvent. /2/ Ethanol. /3/ Glacial acetic acid. /4/ Pyridine. /5/ Dimethylformamide.
/6/ 0.1 N HCl in methanol.

i.v. with Candida albicans, there was a high protection rate following oral doses of 4 mg [11] . In rabbits infected with C. albicans, doses of 40 mg/kg, s.c. or i.v., reduced mortality from 100% to 62% [28] . Doses of 6000 units/egg sterilized 60% of embryonated eggs infected with C. albicans [38] . Median protective dose against Bl. dermatitidis in mice was 0.8 mg/kg/da, i.p., for 10 days [33] . Daily i.p. doses of 20 mg/kg had no inhibitory effect on Ehrlich ascites tumor in mice [34] .

CLINICAL Daily oral doses of 1 g reduced the number of Candida albicans in fecal flora in man [7] . The increase in yeast flora in the gastrointestinal tract accompanying oral tetracycline therapy was counteracted by simultaneous oral administration of 250,000 unit doses of nystatin [9] . Incidence of side effects occasionally associated with oral tetracycline therapy appeared to be reduced when this antibiotic was combined with nystatin for antibacterial therapy. The combination was well tolerated.[22-24] Despite data indicating poor absorption of nystatin from the gastrointestinal tract, a report describes the successful use in systemic moniliasis in which skin and urinary tract infections cleared after 5 days of oral therapy [14] . Monilial infections of the skin responded to topical therapy with fungicidin in a drying lotion base [13] . Favorable responses noted in a variety of monilial infections in patients treated with oral doses of 0.25-1.0 g/da for 1-5 days [10] . Good clinical responses observed in several cases of monilial vulvovaginitis following oral therapy [30] . Further clinical trials have confirmed the value of topical therapy in oral, vulvovaginal, and cutaneous moniliasis [18-21] . Topical application (in propylene glycol or in ointment base) appeared effective in anogenital and vaginal moniliasis [12] . Topical therapy in dermatophytosis gave poor to fair responses [35] . Improvement noted in three cases of disseminated coccidioidomycosis following intravenous therapy; no clinical response in two cases with meningeal involvement.[17] In preliminary trials, total oral doses of 45 million units over a 10-day period cleared the stools of E. histolytica in five cases of amebiasis [16] .

ACUTE TOXICITY LD_{50} in mice, 29,430-50,040 units/kg, i.p.; oral doses of 8.1-12.5 million units tolerated[1]. LD_{50} in rats, 85,068-93,440 units/kg, i.p.; oral doses of 7.68 million units/kg non-toxic.[16] In vitro. Concentrations of 30 units/ml did not interfere with phagocytic activity of human leukocytes [40] . In tissue cultures, using the roller tube method, 1250-2500 units/ml (approximately 625-1250 μg/ml) were required for partial inhibition of human skin explants [29] . Concentrations of 250 units/ml toxic to HeLa (carcinoma) cells; 500 units/ml toxic to "L" cells of Earle and to chick embryo fibroblasts. Concentrations up to 100 units/ml did not interfere with the production of Mahoney (type I) strain of poliomyelitis virus in HeLa cells. In view of the low toxicity, antibiotic appears to be a useful agent for control of mold and yeast contaminations when employed in concentrations of 30 units/ml.[26]

CHRONIC TOXICITY Toxic manifestations were observed in rats receiving daily oral doses of 810,000 units/kg over a 3-month period. No histopathologic changes in dogs receiving 90,000-450,000 units/kg orally for 185-217 days, or i.v. doses of 3200 units/kg/da for 35-37 days.[25] Daily subcutaneous doses of 1250 units (0.5 mg), over periods of 58 days, were well tolerated in hamsters initially weighing 25-30 g, but single doses of 80 mg/kg were toxic [31] . Mice tolerated repeated daily i.p. doses of 24 mg/kg [5] , or 50 mg/kg, s.c., for 10 days [8] . Repeated oral administration of 300 mg/kg in rats and 1000 mg/kg in dogs non-toxic [7] .

In man, there was no evidence of toxicity following 400,000-800,000 units per day, orally, for 22 days [16] . Daily oral doses up to 1.25 g for 30 days were well tolerated without significant side effects [8] .

ABSORPTION AND EXCRETION Poorly absorbed from the gastrointestinal tract of animals and man after oral administration. In dogs, plasma level was 0.9-1.1 units/ml within 2-4 hours after single oral dose of 450,000 units/kg. Following oral dosages of 150,000-260,000 units/kg for 31 weeks, concentrations of 35-150 units/g were noted in the liver and 75 units/g in the kidneys, with no detectable levels in the lungs and spleen.[25]

In man, in a case of coccidioidomycosis treated with 70,000-1,400,000 units per day orally, the plasma level reached 9 units/ml. Following an oral dose of 15 million units, the blood concentration was 9 units/ml four hours later. Intravenous doses of 200,000 units twice daily, followed by four times daily, produced plasma levels of 54 units/ml.[25] No detectable concentrations in the cerebrospinal fluid after intravenous or oral therapy [17] .

RESISTANCE Resistance in C. albicans failed to develop in vitro, or was of very low order following repeated transfers in the antibiotic. Reciprocal cross-resistance of low magnitude displayed between nystatin and other polyene-type antibiotics (rimocidin, candicidin, ascosin, trichomycin, candidin B), but not with non-polyene types (gliotoxin, comirin, aspergillic acid, streptothricin).[27]

MODE OF ACTION Action is fungicidal as well as fungistatic. A strain of C. albicans, which was inhibited by 8 units/ml in vitro, was rendered non-viable within 6 hours when exposed to 32 units/ml.[36] A suspension, containing 3.0×10^{9} living C. albicans cells per ml, was killed by a concentration of 1 mg/ml of the antibiotic [28] . In vitro concentrations of 3 μg inhibited aerobic and anaerobic utilization of glucose, maltose, or fructose by yeast, and also eliminated endogenous uptake. Higher concentrations had no effect on glucose utilization by Escherichia coli and Streptococcus faecalis which are not sensitive to fungicidin.[39]

MISCELLANEOUS Yeast contaminations were controlled by incorporating 20-80 units of fungicidin per ml in cultures examined for foot-and-mouth disease virus. The following species of yeast were inhibited: Endomycopsis, Saccharomyces, Sporobolomyces, Kloeckera, Trichosporon, Rhodotorula.[15] Concentrations of 20 μg/ml useful

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/1/ Most preparations assay 2.3-2.5 units/μg.

for controlling fungal contaminations in fecal, sewage, and polluted water samples in laboratory examinations for isolation of enteric viruses [37] . Nystatin shows molluscacidal activity; concentrations of 15.6 μg/ml were lethal to snails (Australorbis glabratus) in one hour [32] .

228. OLEANDOMYCIN

(Antibiotic PA-105, Amimycin)
Trademark of Chas. Pfizer & Co., Inc., for oleandomycin is Matromycin.

SOURCE Streptomyces antibioticus [1] .

NATURE Basic [1] .

MOLECULAR FORMULA $C_{37}H_{67}NO_{13}\cdot HCl$ (possible) [1] .

MELTING POINT (°C) Dihydrate: 134-135. Anhydrous HCl: 125-128 [1] .

OPTICAL ACTIVITY Dihydrate: $[\alpha]_{D}^{25} = -54^{\circ}$[1] [1] .

UV ABSORPTION MAXIMUM 286-289 mμ [1] .

STABILITY Stable at room temperature at pH 2-9 in aqueous solution [1] .

OTHER REACTIONS Found: C, 57.63; H, 8.73; N, 1.87; Cl, 4.30 (ionic). Reduces Fehling slowly; positive Tollens; negative $FeCl_3$; ninhydrin.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Streptococcus pyogenes, Hemophilus pertussis, 0.08; Erysipelothrix rhusiopathiae, 0.2-0.4; Bacillus subtilis, 0.4; Micrococcus pyogenes var. aureus, Diplococcus pneumoniae, 0.2-1.6; Clostridium tetani, 0.8; Corynebacterium diphtheriae, Listeria monocytogenes, Neisseria meningitidis, Mycobacterium phlei, Myco. smegmatis, Mycobacterium sp, 1.6; N. gonorrhoeae, N. catarrhalis, 3.2; Cl. sporogenes, Brucella bronchiseptica, 6.2. Most Gram-negative bacteria, e.g., Aerobacter aerogenes, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus vulgaris not sensitive to 100 μg/ml.[1]

In vivo. S.c. doses of 15-30 mg/kg protected mice against infections with Str. pyogenes and M. pyogenes var. aureus [1] .

CLINICAL Favorable responses in 20 cases of bacterial pneumonia and in 13 cases of possible staphylococcal enteritis in children treated with 40 mg/kg daily in 6-hour divided oral doses for 5-7 days. Little or no response in cases of enteritis caused by Salmonella sp, or Shigella paradysenteriae.[2]

PHARMACOLOGY LD_{50} in mice, 550 mg/kg, i.v. Following oral administration of 200 mg/kg in rabbits, peak blood concentration of 3.8 μg/ml in 1 hour noted, with 0.2-0.4 μg in 5-7 hours.[1] Daily oral doses of 40 mg/kg for 5-8 days appeared to be well tolerated in children [2] .

RESISTANCE Cross resistance with erythromycin and carbomycin has been described [1] . In another report, 22 erythromycin-resistant strains of M. pyogenes var. aureus were all sensitive to oleandomycin.[2]

229. OLIGOMYCIN

SOURCE Streptomyces sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{25}H_{40-42}O_{7}$ (proposed); 408, 439 (Rast); 454 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless, hexagonal crystals [1] .

MELTING POINT (°C) 135.8-136.3 (uncorr.) [1] .

OPTICAL ACTIVITY $[\alpha]_{D}^{25.8} = -51^{\circ}$[2] [1] .

UV ABSORPTION MAXIMA 225, 232 mμ[1] [1] .

SOLUBILITY s. most organic solvents; sl. s. petroleum ether, cyclohexane, water [1] .

STABILITY Thermo-, acid, and alkali stable [1] .

OTHER REACTIONS Br in CCl_4 and $KMnO_4$ in acetone slowly decolorized; negative phenolic, $FeCl_3$, digitonin; positive 2, 4-dinitrophenylhydrazine; a second component present at start of purification.[1]

QUANTITATIVE DETERMINATION Microbiological: Blastomyces dermatitidis [1] .

/1/ Methanol. /2/ c, 3 methanol.

229. OLIGOMYCIN (Concluded)

BIOLOGICAL ACTIVITY Active against filamentous fungi; no activity against bacteria and yeasts. In vitro. Inhibits Aspergillus fumigatus, Ascochyta pinodella, Bl. dermatitidis, Chalara quercina, Cladosporium cucumerinum, Colletotrichum circinans, C. lagenarium, C. pisi, Glomerella cingulata, Histoplasma capsulatum, Monilia nigra, Penicillium expansum, P. notatum, Verticillium alboatrum, 8.0 μg/ml.[1] Oligomycin was the most effective of 8 antibiotics tested against Tilletia caries (wheat smut fungus), causing complete inhibition of flask cultures at concentrations of 0.4 μg/ml [2] .

TOXICITY LD_{100} in mice, 2.5 mg/kg, i.v. or i.p. [1] . Sprays containing 3000 ppm of antibiotic were non-toxic in various plants. Seeds treated with 100-150 ppm germinated normally.[3]

PHYTOPATHOLOGY Greenhouse experiments indicate that the antibiotic may be added to the soil without decreasing soil microflora, and is detected in stems of various plants. Under these conditions alfalfa seed was protected against damping off caused by Pythium sp.[3]

230. OREGONENSIN

SOURCE Ganoderma oregonense [1] .

NATURE Neutral [1] .

MOLECULAR FORMULA $C_{20}H_{32}O_8$ (proposed) [1] .

CRYSTAL FORM AND COLOR White needles [1] .

MELTING POINT (°C) 82 [1] .

OPTICAL ACTIVITY Inactive [1] .

UV ABSORPTION MAXIMUM 325 mμ [1] .

SOLUBILITY s. most organic solvents; sl. s. water; i. petroleum ether.[1]

STABILITY Thermo- and alkali labile [1] .

OTHER REACTIONS Positive 2,4-dinitrophenylhydrazine; negative Tollens.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus in dilution of 1:800,000; Mycobacterium phlei, 1:100,000; Streptococcus pyogenes, Escherichia coli, 1:50,000. Inactivated in vitro in presence of 50% serum.[1]

231. ORYZASIZINE
(Oryzacidine)

SOURCE Aspergillus oryzae [2] .

MOLECULAR FORMULA $C_8H_{13}O_5N$ [1,2] .

CRYSTAL FORM AND COLOR White needles; hygroscopic [1,2] . Quinine salt: white tablets [2] .

MELTING POINT (°C) 162-163 (d.) [1,2] . Quinine salt: 210 (d.) [2] .

OPTICAL ACTIVITY $[\alpha]_D = -138^\circ$ [1] ; $[\alpha]_D^{13.5} = -133^\circ$ [2] .

SOLUBILITY s. water, methanol, ethanol, propanol, hot acetone; sl. s. butanol, ethyl acetate; i. ether, acetone, chloroform, carbon tetrachloride.[2]

BIOLOGICAL ACTIVITY In vitro. Active against saké putrefying bacteria in dilution of 1:300,000 [2] .

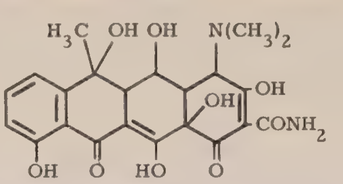
232. OXYTETRACYCLINE
The trademark of Chas. Pfizer & Co., Inc., for oxytetracycline is Terramycin.

SOURCE Streptomyces rimosus [1] .

NATURE Amphoteric [2,3] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{24}N_2O_9$ [3,6] ; approximately 440 (ebull.); 462.5 ± 5 (X ray).[3,8]

STRUCTURE



[5, 6]

CRYSTAL FORM AND COLOR Pale yellow needles; thick, hexagonal plates [1-3] .

MELTING POINT (°C) Dihydrate: 181-182 (d.). Anhydride: approximately 185 (d.). HCl: 190-194 (d.). [1-3, 6]

OPTICAL ACTIVITY Dihydrate: $[\alpha]_D^{25}$ = -196.6°[1], -2.1°[2], +26.5°[3].[2, 3, 6]

UV ABSORPTION MAXIMA 270, 370 mμ[4]; 270, 359 mμ[5]; 245, 264, 375 mμ[6]. Dihydrate: 249, 276, 353 mμ[7]; 268, 353 mμ[8].[2, 3, 6]

SOLUBILITY s. acids, alkalies; sl. s. acetone, ethanol, chloroform, water; i. ether. HCl: s. water; i. ether, petroleum ether, benzene.[1-3]

STABILITY Stable at acid pH; decreasing stability at pH 7 and above at 37°C.[1-3]

OTHER REACTIONS Positive $FeCl_3$, Pauly, Friedel-Crafts, Fehling, Molisch; HCl pK'_a 3.49, 7.55, 9.24 in aqueous solution; forms complexes with inorganic salts; Ba-Ca and Ba-Mg salts very insoluble in water and precipitate readily from aqueous solution at pH 8.5-9.5; no infrared bands below 5.9 μ; dihydrate crystals biaxial negative with parallel extinction, $\alpha = 1.634 \pm 0.004$, $\beta = 1.646 \pm 0.004$, $\gamma = >1.70$.[3, 6, 8]

QUANTITATIVE DETERMINATION Microbiological: Klebsiella pneumoniae, Micrococcus pyogenes var. aureus [2, 3] . Colorimetric [4, 7] . Spectrophotometric [4] .

BIOLOGICAL ACTIVITY Active against Gram-positive and Gram-negative bacteria, rickettsiae and larger viruses, and certain protozoa. No activity against fungi. In vitro. Most strains of the following actinomycetes or bacteria are sensitive to 0.002-7.5 μg/ml: Actinomyces bovis, Bacillus anthracis, B. mycoides, B. subtilis, Brucella abortus, Br. bronchiseptica, Br. melitensis, Br. suis, Clostridium botulinum, Cl. tetani, Cl. feseri, Cl. histolyticum, Cl. hemolyticum, Cl. novyi, Cl. perfringens, Corynebacterium diphtheriae, Corynebacterium spp, Diplococcus pneumoniae, Erysipelothrix rhusiopathiae, Escherichia coli, Hemophilus influenzae, H. pertussis, Klebsiella pneumoniae, Listeria monocytogenes, Micrococcus pyogenes var. aureus, Mycobacterium tuberculosis, Myco. smegmatis, Myco. avium, Myco. phlei, Neisseria catarrhalis, N. gonorrhoeae, N. meningitidis, Pasteurella multocida, Past. pestis, Salmonella typhosa, S. paratyphi, S. enteritidis, S. pullorum, Shigella dysenteriae, Streptococcus agalactiae, Str. dysgalactiae, Str. faecalis, Str. pyogenes, Str. viridans, Vibrio comma. Generally less sensitive (10-50 μg/ml): Nocardia asteroides, Aerobacter aerogenes, Salmonella spp, Shigella spp, Cl. bifermentans. Most strains of Pseudomonas aeruginosa and Proteus spp are resistant, >50 μg/ml.[9-20] Spirochetes and protozoa (μg/ml): Borrelia recurrentis inhibited by 1.0 [21] ; Trichomonas vaginalis, 125-250 [22] ; Entamoeba histolytica, 31.2-250.[23] Inhibits H. aegyptius, cause of conjunctivitis in man, at 0.4-6.25 μg/ml; also active against this agent in chick embryos.[125] Rous sarcoma virus inactivated by exposure to antibiotic as demonstrated by failure to develop tumors in chickens [24] . Penetrated rabbit macrophages and suppressed growth of intracellular Myco. tuberculosis [25] .

In vivo. S.c. doses of 200-300 mg/kg afforded protection against experimentally induced s.c. infections with T. vaginalis in mice [126] . 0.5-1.0 mg/ml in drinking water was effective in mice in controlling experimental airborne mouse pneumonitis virus infections [127] . In mice, single s.c. doses of 6.5-30 mg/kg, or totals of 0.25-20 mg/kg in divided doses, gave good protection against infection with Str. pyogenes, K. pneumoniae, H. influenzae, Salmonella typhosa, S. choleraesuis, S. enteritidis, S. typhimurium, with somewhat higher doses required for D. pneumoniae, Cl. septicum, Cl. tetani, Higher oral doses were also protective.[9, 12] Was the most effective of several antibiotics tested against experimental Cl. tetani infection; complete protection obtained with 5 daily parenteral doses of 5 mg/kg in hamsters and with 20 mg/kg in mice and rabbits [133] . Doses of 2.5-10 mg/kg, administered i.p., gave high protection in mice against Cl. perfringens, Cl. histolyticum, Cl. bifermentans and Cl. novyi [16] ; similar levels were effective against M. pyogenes var. aureus, Past. multocida, B. anthracis; higher doses of 20-80 mg/kg required against Ery. rhusiopathiae and L. monocytogenes in mice or S. gallinarum in chicks. [27] Daily oral doses in mice had a suppressive effect on infection with Br. melitensis [28] ; also highly effective against V. comma [20] and Past. tularensis [38] . Oral doses of 100 mg/kg afforded high protection, but failed to be curative, in infant rabbits infected intra-intestinally with V. comma [132] . High activity in mice or rats infected with Borrelia novyi, B. duttoni [9, 30] , and against B. anserina in chicks treated with low doses [31] . Effective in experimental rabbit syphilis, but less active on a weight basis than penicillin [33] ; suppressive effect noted in experimental toxoplasmosis in mice [32] . Showed activity in mice and guinea pigs infected with Myco. tuberculosis, including strains which were streptomycin-resistant [26, 29] . Active against Plasmodium spp in mice, chicks

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/1/ c, 1 in 0.1 N HCl. /2/ c, 1 in 0.1 N NaOH. /3/ c, 1 methanol. /4/ Methanol. /5/ 0.01 N methanolic HCl. /6/ 0.01 N methanolic NaOH. /7/ 0.1 M KH_2PO_4 pH 4.5. /8/ Phosphoric acid pH 1.7.

and canaries [34] , and Bartonella muris infections in rats [44] . Oral medication highly effective in suppressing pinworm (Aspiculuris tetraptera) infestation in mice; little or no effect on hookworm or tapeworm in dogs and cats. [40] High anti-rickettsial activity in chick embryos or mice against rickettsiae of epidemic typhus, murine typhus, scrub typhus, rickettsialpox, Rocky Mt. spotted fever [35-38] . Active in chick embryos against pleuropneumonia-like organisms isolated from chronic respiratory disease of poultry [130] . Doses as low as 0.031 mg protected chick embryos against feline pneumonitis virus [131] . In mice, antibiotic is highly protective against gray lung virus [41] and experimental infection with feline pneumonitis virus [42] . No activity against the viruses of rabies, herpes simplex or influenza A [39, 46] . Daily i.p. doses of 150 mg/kg in mice had a moderate inhibitory effect on sarcoma 180 and carcinoma 1025 [136, 137] . High i.p. doses of 250-350 mg/kg/da slightly retarded development of Crocker sarcoma 180 in mice [43] . Heavy i.p. doses of 150 mg/kg had an adverse effect on Candida albicans, enhancing infections in mice [58, 59] . Single i.m. doses of approximately 110 mg/kg had a stimulatory effect on spermatogenesis in rats [60] .

CLINICAL This broad-spectrum antibiotic has established usefulness in a variety of infections caused by Gram-positive and Gram-negative bacteria, spirochetes, rickettsiae and the larger viruses of the psittacosis-lymphogranuloma venereum group. The drug may be administered orally, with usual doses for adults of 1 g/da, or 2 g in severe infections; as much as 4 g/da dosages are well absorbed and usually well tolerated. In children with severe infections, total daily oral doses of 25-40 mg/kg are regarded as adequate.[45, 61] Total oral doses of 3-29.5 g, administered over periods of 3-8 days, successfully treated cases of anthrax infection in man [138] . In 7 cases of tick-borne relapsing fever in East Africa, treated with 4 oral daily doses of 500 mg in 2 days, there was prompt response and rapid disappearance of parasitemia; one patient relapsed on the 14th day after treatment.[139] Medication by the i.v. and i.m. routes, as well as by topical application, has frequently been used [45, 61] . Single intramuscular doses of 400 mg were successfully used in the treatment of gonorrheal urethritis [140] .

Oxytetracycline has proven highly effective in the treatment of infections caused by streptococci, micrococci, bacteroides, brucellae, D. pneumoniae, and in urinary tract infections caused by susceptible organisms. It is useful for pre- and postoperative prophylaxis in surgical procedures on the large bowel, and in the treatment of peritonitis and respiratory infections. Highly effective in rickettsioses (Rocky Mt. spotted fever, epidemic typhus, scrub typhus, rickettsialpox and Q fever); it is also of value in lymphogranuloma venereum and granuloma inguinale. [36-38, 45, 61, 62, 124] This drug and chlortetracycline described as antibiotics of choice in psittacosis [52] . Conflicting results have been reported in pertussis, herpes zoster, infectious mononucleosis and leptospirosis; the direct action of this and other antibiotics in these conditions is debatable.[45, 47, 48] Very effective in gonorrhea; preliminary trials in syphilis gave variable results.[47, 51, 76] Combination with streptomycin in pulmonary tuberculosis described as promising, with the advantage that strains resistant to either antibiotic may not emerge [49, 50] . Favorable clinical response in yaws [53] , primary atypical pneumonia [54] , Plasmodium vivax and P. falciparum malaria [55] , and in amebic dysentery [56, 57] . Excellent response in pinworm infestation (Enterobius vermicularis) following 1-2 g daily oral doses for one week [63, 89] . Favorable results in cervicofacial actinomycosis [64] , Balantidium coli infection [65] , and in non-gonococcal urethritis [66, 67] . Intramuscular preparations in doses of 50-200 mg have given good results in systemic infections [68, 69] ; subcutaneous route also employed in infants [70] . Meningitis caused by H. influenzae or N. meningitidis has responded favorably to i.m. or i.v. administration of the antibiotic, with or without sulfadiazine [71, 72] . Topical therapy is effective in a variety of ocular infections, including trachoma, and in various skin infections [61, 73, 74, 78] ; good results also obtained in vaginitis caused by Trichomonas vaginalis [75] . Little or no evidence that this (or other) antibiotic is of direct value in measles, mumps, common cold, viral hepatitis, varicella, smallpox, viral encephalitides, influenza, or lymphocytic choriomeningitis [45, 47] . Ineffective in mumps orchitis [77] . Oral medication with this or other broad spectrum antibiotics failed to influence the course of the following dermatoses: herpes simplex, lichen planus, plantar warts, pityriasis dermatitis, herpetiformis, and discoid eczema [128] . Oral therapy with oxytetracycline or other antibiotics was of no value in Reiter's syndrome [167] .

VETERINARY Intramammary infusions of value in bovine mastitis [79, 83] . Useful in control of bovine anaplasmosis [80] ; in experimental anaplasmosis in splenectomized calves, the numbers of Anaplasma marginale in the red cells were decreased following therapy [144] . Intratracheal and intrathoracic injections of value in treating infectious rhinotracheitis and chronic pneumonia in cattle [145] . Preliminary trials indicate intravenous therapy with 0.5-1.0 g effective in tick-borne fever in bovines [146] . Good clinical responses in strangles and upper respiratory diseases in equines, pneumo-enteritis complex and metritis in cattle, and necrotic enteritis in swine [94] . Intramuscular injection of a single 1 g dose in nursing sows successfully controlled peracute gastroenteritis (scours), characterized by a profuse diarrhea, in their baby pigs. Presumably these doses gave adequate therapeutic levels in the milk.[147] Oxytetracycline or penicillin at levels of 15 mg/lb body weight, failed to protect weanling pigs against swine erysipelas experimentally induced by intradermal injection of cultures of Erysipelothrix rhusiopathiae [148] . Oral doses of 50-160 mg/kg were highly effective in prophylaxis of an artificially induced enzootic (virus) pneumonia in pigs [149] . Preliminary trials indicate value of oral therapy in controlling contagious pleuropneumonia in goats [129] . Experimental infections with Neorickettsia helmintheca (salmon poisoning) in dogs responded to oral therapy [150] . Favorable results in canine practice in pneumonia and wound infections [91, 92] . Oral medication in cats useful for control of feline pneumonitis and infectious panleucopenia [151] . Useful in control of chronic respiratory disease and infectious sinusitis in poultry [81, 82] . Effectively controlled natural psittacosis and ornithosis in parakeets and pigeons [84] , and salmonellosis in poultry [93] . Was the most effective of several antibiotics tested against experimental fowl cholera; a single intramuscular injection of 25 mg/kg was curative when given 6-24 hours after infection of chickens with Past. multocida.[141] Experimentally induced infectious synovitis in chicks, a disease of unknown etiology, was clinically controlled by feeding 200 ppm in feed for 2-3 weeks [135] . Feeding at levels of 200 g per ton of feed for 7-10 weeks did not markedly alter in chickens the clinical course of chronic respiratory disease associated with pleuropneumonia-like organisms [142] . Was ineffective in controlling an outbreak of blue comb disease in turkeys, a disease of undetermined etiology [143] .

ACUTE TOXICITY LD_{50} in mice, 178 mg/kg, i.v.; 650-892 mg/kg, s.c.; 6696-7200 mg/kg, oral. LD_{50} in rats, 260 mg/kg; in rabbits, approximately 75 mg/kg; in dogs, approximately 150 mg/kg, i.v. Liver and kidney function not affected by these doses. No effect on smooth muscle of isolated intestines or uteri of guinea pigs and rabbits; no effect on blood sugar level. I.v. injection in anesthetized dogs and cats had no effect on blood pressure. Rabbits tolerated intracisternal injection of 2 mg [85-87] . In vitro. Oxytetracycline and tetracycline, but not chlortetracycline, in tissue cultures in concentrations of 50 μg/ml had a growth-stimulating action on embryonic cardiac tissues of the chick. All three antibiotics were toxic to the fibroblasts in concentrations over 100 μg/ml.[152] Concentrations of 100-200 μg/ml in tissue cultures inhibited outgrowths of skin tissue [88] . Using the roller tube method of tissue culture, concentrations of 1250 μg/ml were required for partial inhibition of human skin explants [153] .

CHRONIC TOXICITY Daily oral doses of 75-200 mg/kg for 6-8 weeks were well tolerated in mice, rats and dogs. In dogs, daily i.m. doses of 75 mg/kg for 77-90 days were non-toxic.[85] When incorporated in the diet at high levels (0.02-0.04% or approximately 20-25 mg/kg/da) and fed continually for 7-11 months, the average life span of rats was decreased by approximately 10% [90] . The antibiotic, like other tetracyclines, is poorly tolerated in guinea pigs and in hamsters. Oral doses of 50 mg/kg/da for 3 days in Syrian hamsters produced a frequently fatal diarrhea with necrosis of intestinal mucosa. This effect was largely prevented by concurrent administration of 125-500 mg/kg of sulfaguanidine.[154]

In man, daily oral doses of 15-30 mg/kg usually were well tolerated, although nausea, vomiting and diarrhea were noted in some patients, especially after higher dosages. Secondary infections with yeast-like organisms have occurred, particularly in the peri-anal region and on the mucous membranes of the vagina and lower rectum after therapy with broad spectrum antibiotics. Allergic reactions following topical use and other side effects have been occasionally reported.[45, 61, 95, 96, 124] Continued topical use of dermatological preparations containing 3% of the antibiotic is associated with a relatively low index of sensitization, in contrast to the sulfonamides, penicillin, and streptomycin [155] .

RESISTANCE Resistant variants did not readily develop in vitro. Following 40 transfers in antibiotic, a 4 to 64-fold increase developed in some strains.[13] In clinical experience, resistant strains of M. pyogenes var. aureus have emerged in considerable numbers, although this has not become a problem with other bacteria. Organisms developing resistance generally exhibit cross resistance to other tetracycline antibiotics.[101-103, 113]

ABSORPTION AND EXCRETION Readily absorbed after oral or parenteral administration, with wide distribution in the tissues and body fluids. In rabbits, single oral doses of 500 mg/kg produced substantial levels in blood, skin, liver, kidneys, lungs, spleen, heart, brain, bile, urine and gastrointestinal tract.[97] In mice, antibiotic accumulated in the reticuloendothelial system with high concentrations in the liver and kidney, with lowest concentration in muscular, bone and nervous tissue [104] .

In man, following single oral dose of 0.5-1.0 g, oxytetracycline produced serum concentration of 1-3 μg/ml, declining after 6 hours, and with peak urine levels of 300 μg/ml in approximately 4 hours. After 1.0-1.25 g, six hourly, a blood concentration of 4-8 μg was maintained. Antibiotic did not readily traverse the blood-brain barrier, but diffused through the placenta and into the pleural fluid at therapeutic levels. Appeared in the bile in concentrations of approximately 4-8 times that of the blood, and approximately 8% of the total ingested was recovered in active form in the urine in 24 hours.[97, 98, 100] Administration of i.m. preparations provided effective blood levels for approximately 8 hours [99] .

MODE OF ACTION Action is primarily bacteriostatic, but may be bactericidal in very high concentrations [9] . Acts primarily on actively multiplying bacteria [105] . Experiments in leucopenic rabbits suggest this drug (also penicillin) may be bactericidal in vivo in absence of cellular and humoral defenses of host [112] . Interferes with synthesis or metabolism of protein in M. pyogenes var. aureus [107, 108] . Inhibits adaptive enzyme formation in E. coli growing in medium containing lactose [109] . Acts on phosphorylation systems by inhibiting acid-soluble organic P fraction [110] . Concentrations of 100-300 μg/ml inhibit oxidation of glutamate and thus the respiration of murine and epidemic typhus rickettsiae in vitro [106] . Antibacterial activity reversed by Mg^{++} and other multivalent cations [111] .

ANIMAL NUTRITION Animal feeds containing supplements of this or other antibiotics have found wide usage for growth stimulation and improvement of feed efficiency. Good growth responses have been noted in pigs, young calves, lambs and poultry, and also in experimental animals.[114-119] When fed at levels ordinarily recommended for other species of animals, no growth improvement was noted in young rabbits fed a pelleted natural ration containing oxytetracycline or chlortetracycline [156] . (For additional data, see chlortetracycline.)

MISCELLANEOUS Showed stimulatory effect on seed germination of sorrel, cucumber and sweet corn [120] . Accelerated photosynthesis and induced an abnormal increase in sucrose in the alga, Scenedesmus [121] . Low concentrations highly effective in control of European foul brood, a bacterial disease of the honey bee, when dusted

232. OXYTETRACYCLINE (Concluded)

over brood frames [122] . Effective in prevention of bacterial spoilage of fish and meat [123] . Addition of approximately 250 mg to 5 gallons of aquarium water of value in treatment of certain diseases of tropical fishes, e.g., columnaris disease, furunculosis, gill disease, fin-rot and tail-rot [157] . Solutions containing 1 mg/ml were well tolerated over 24-hour periods by viviparous fish (guppies) [158] . Relatively high levels (300-500 mg per 14 g of wheat) of oxytetracycline and certain other antibiotics were lethal to several varieties of coleopterous stored-grain insects within 30-60 days [159] . The median lethal dose, by injection, in the German cockroach (Blatella germanica) was 90-165 μg [160] . Oxytetracycline alone, or in combination with dihydrostreptomycin, when fed at levels of 0.2 g (in sugar water) per honeybee colony, effectively controlled European foul brood (probably caused by Bacillus pluton). Was less effective against diseased colonies when applied as a spray in a thin mist to the brood frames.[161] Intraperitoneal injection of 1-3 mg per lb body weight in beef cattle, sheep and hogs, 1-4 hours prior to slaughter, assured tissue levels which were adequate for preserving the meat and controlling spoilage [134] . Levels of 20 μg/ml completely prevented crown gall development in tomato plants induced with Agrobacterium tumefaciens [162] . Foliage sprays with the antibiotic, especially in combinations with streptomycin, were highly effective in control of fireblight caused by Erwinia amylovora in apple and pear trees [163] . A combination of 1.5% oxytetracycline and 15% streptomycin was effective against a wide variety of plant pathogens and has been effectively used for controlling diseases of potato, tomato, apple, pear, pepper, walnut, and tobacco [164]. After darkening one cotyledon of a cucumber seedling, there is increased growth of that side of the hypocotyl; addition of oxytetracycline or leucomycin to the soil markedly increases the resulting curvature of the seedling.[165] Growth of wheat roots in distilled water was stimulated by addition of 0.1-3.2 ppm of crude oxytetracycline (502 μg/mg). Injury to roots by higher concentrations of the antibiotic (10-32 ppm) was reduced by addition of calcium ions [166] .

233. ANTIBIOTICS PA-114

SOURCE Streptomyces olivaceus [1] .

NATURE PA-114 A: neutral.
B: weakly acidic [1] .

MOLECULAR FORMULA AND WEIGHT PA-114 A: $C_{25}H_{31}N_3O_6$ or $C_{35}H_{42}N_4O_9$; 525 (roentgen ray); 546 (Signer); 469.5, 662.7 (calc.).[1]
B: $C_{52}H_{63}N_9O_{12}$ (proposed); 981 (roentgen ray); 1006 (calc.).[1]

CRYSTAL FORM AND COLOR PA-114 A: colorless, crystalline needles[1].
B: colorless tablets[2]; feathery needles[3].[1]

MELTING POINT (°C) PA-114 A: 200 (d.).
B: 265 (d.).[1]

OPTICAL ACTIVITY PA-114 A: $[\alpha]_D^{25} = -207^\circ$.
B: $[\alpha]_D^{25} = -59.7^\circ$.[1]

UV ABSORPTION MAXIMA PA-114 A: 220-230, 275 mμ[4].
B: 260, 305 mμ[4].[1]

OTHER REACTIONS Synergistic effect when A and B are both present.

PA-114 A: positive $FeCl_3$ (green), neutral permanganate, Br in CCl_4, Tollens, 2,4-dinitrophenylhydrazine, copper acetate; negative Fehling, Molisch, Millon, ninhydrin.

B: positive $FeCl_3$ (red), neutral permanganate, Br in CCl_4; negative Tollens, 2,4-dinitrophenylhydrazine, copper acetate, Fehling, Molisch, Millon, ninhydrin.[1]

BIOLOGICAL ACTIVITY In vitro. When tested individually, products A and B showed lower activity than their combination. The combination is primarily active against Gram-positive bacteria. Inhibits (μg/ml) Streptococcus pyogenes, 0.08; Erysipelothrix rhusiopathiae, <0.19-0.39; Micrococcus pyogenes var. aureus (including strains resistant to penicillin, streptomycin, the tetracyclines, erythromycin, polymyxin, and carbomycin), <0.19-1.56; Str. faecalis, Corynebacterium diphtheriae, C. pseudodiphtheriticum, 0.39; Diplococcus pneumoniae, 0.39-6.25; Bacillus subtilis, Clostridium perfringens, Cl. tetani, 0.78; B. anthracis, 1.56; Corynebacterium xerose, Listeria monocytogenes, Neisseria gonorrhoeae, N. catarrhalis, N. meningitidis, Hemophilus pertussis, Mycobacterium smegmatis, 3.12; Mycobacterium sp, 6.25; Brucella bronchiseptica, 12.5; Aerobacter aerogenes, 50-100; Escherichia coli, Pseudomonas aeruginosa, 100; Proteus vulgaris, Salmonella typhosa, S. paratyphi, Klebsiella pneumoniae, >100. Candida albicans and Trichophyton sulfureum resistant to 100 μg/ml. In vitro activity not altered in presence of serum. [2]

In vivo. Good protection afforded in mice by 50 mg/kg, s.c., or 100 mg/kg, oral, against Str. pyogenes and M. pyogenes var. aureus. Less effective against infection with D. pneumoniae. When used individually, products A and B were practically inactive against Str. pyogenes infection. For in vivo activity, product A was more critical than B; approximately 5% of B in combination with A was required for optimal activity.[2]

/1/ From n-butylethyl ketone. /2/ From methanol. /3/ From toluene. /4/ Methanol.

233. ANTIBIOTICS PA-114 (Concluded)

TOXICITY   Mice tolerated s.c. and oral doses of 200 mg/kg.[2]

ABSORPTION AND EXCRETION   Poorly absorbed in rabbits, with no detectable plasma levels following oral dosage of 100 mg/kg. Intramuscular dosage of 200 mg/kg produced blood levels of approximately 1 μg/ml in 1-5 hours, dropping to 0.2 μg/ml in 7 hours. In rats, oral doses of 100 mg/kg produced peak blood levels of 0.1 μg/ml in 1-3 hours.[2]

234. PALITANTIN

SOURCE   Penicillium palitans [1] .

NATURE   Unsaturated dihydroxyaldehyde [1] .

MOLECULAR FORMULA AND WEIGHT $C_{14}H_{22}O_4$ [1, 2] ; 256 (cryo.); 254 (calc.).[1]

CRYSTAL FORM AND COLOR   Colorless needles [1] .

MELTING POINT (°C)   163 [1] .

OPTICAL ACTIVITY $[\alpha]^{23}_{5461} = +4.4°$/1/ [2] .

SOLUBILITY   s. hot water, alcohol, chloroform; sl. s. cold water, ether.[1]

OTHER REACTIONS   Closely associated with, and structurally related to, frequentin; positive Schiff; reduces silver oxide; readily oxidized by potassium mercuriodide to the corresponding acid.[1, 3]

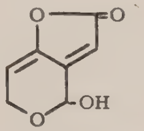
235. PATULIN
(Clavacin, Clavatin, Claviformin, Expansine, Penicidin)

SOURCE   A variety of Penicillium spp and Aspergillus spp [1-4, 9, 10] ; by synthesis [28] .

NATURE   Neutral [3] .

MOLECULAR FORMULA AND WEIGHT $C_7H_6O_4$ [2, 4, 5, 7] ; 169 (Rast); 154 (calc.).[2]

STRUCTURE



[8]

CRYSTAL FORM AND COLOR   Colorless, rhomboid plates or prisms [1-3, 5] .

MELTING POINT (°C)   111-112 [3] .

OPTICAL ACTIVITY   Inactive [1, 3, 5] .

UV ABSORPTION MAXIMUM   276 mμ [2, 7] .

SOLUBILITY   s. water, alcohol, acetone, chloroform, ether, dilute alkali; i. petroleum ether, benzene.[1, 5]

STABILITY   Thermostable; rather alkali labile.[1, 3]

OTHER REACTIONS   Negative $FeCl_3$, Schiff; red color with alkali; yellow with dilute ammonia, piperidine, asparagine, amino acids, peptones without loss of activity; loss on repeated crystallization; reduces ammoniacal $AgNO_3$, Fehling, $KMnO_4$; yellow crystals with 2, 4-dinitrophenylhydrazine; inhibited by serum, cysteine.[1, 4-6]

QUANTITATIVE DETERMINATION   Microbiological: Escherichia coli, Micrococcus pyogenes var. aureus [2, 5] .

BIOLOGICAL ACTIVITY   Active against Gram-positive and Gram-negative bacteria, fungi. In vitro. Inhibits Sarcina lutea in dilution of 1:500,000; Salmonella typhosa, S. choleraesuis, S. paratyphi, S. typhimurium, Proteus vulgaris, 1:80,000-1:400,000; Bacillus cereus, B. megatherium, B. mycoides, B. subtilis, 1:100,000-1:200,000; S. enteritidis, S. schottmuelleri, Shigella dysenteriae, Sh. paradysenteriae, Pseudomonas aeruginosa, Aerobacter aerogenes, E. coli, Neisseria catarrhalis, Diplococcus pneumoniae, M. pyogenes var. aureus, Streptococcus pyogenes, Str. viridans, 1:33,000-1:80,000.[1, 4, 11-13]   Fungi: Trichophyton mentagrophytes, Candida albicans, 1:2500-1:5000 [14] . Microsporum audouini, Epidermophyton cruris, Trichophyton spp, Microsporum spp,

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/1/ c, 0.8 chloroform.

235. PATULIN (Concluded)

1:40,000-1:160,000 [15] . Phytopathogens: Pythium ultimum, 1:800,000; Phytophthora erythroseptica, 1:320,000; Rhizoctonia solani, Stereum purpureum, Claviceps purpurea, 1:20,000-1:80,000; Verticillium dahliae, Sclerotinia sclerotiorum, Rhizoctonia crocorum, Penicillium digitatum, 1:5000.[16] Dilution of 1:50,000 markedly stimulated cell proliferation, migration of leukocytes, and inhibited carcinoma cells in tissue culture [17] . Solutions of 1 mg/ml destroyed viability of sarcoma 180 and a mouse melanoma, but had little or no effect in vivo [18] . Inactivated tetanus toxin [19] . Dilution of 1:1,000,000 lethal to Chilomonas paramecium [2] .

In vivo. No activity in mice infected with Salmonella schottmuelleri [20] ; inactive against experimental infections with M. pyogenes var. aureus, Str. pyogenes, D. pneumoniae, Corynebacterium diphtheriae, Clostridium perfringens, Salmonella typhimurium, Mycobacterium tuberculosis, Leptospira icterohemorrhagiae, and the viruses of vaccinia, influenza and herpes [21] . Daily i.p. doses of 2 mg/kg for 5 days had a suppressive effect on Ehrlich ascites tumor in mice [29] . No activity against Plasmodium gallinaceum in chicks [22] .

CLINICAL Topical use in common cold gave indifferent results [23] . Ointment of slight value in skin infections [21] .

PHYTOPATHOLOGY Solution containing 1:20,000 patulin failed to control Ustilago tritici infection of wheat [24] .

ACUTE TOXICITY LD_{50} in mice, approximately 25-35 mg/kg, i.v.; 10-15 mg/kg, s.c.; 35 mg/kg, oral. LD_{100}, 5-10 mg/kg, i.p.[1,4,11,23,25] Marked antidiuretic effect in cats; sublethal doses produced severe pathological changes in viscera and tissues [2,23,25] . In vitro. Dilution of 1:800,000 toxic to leukocytes [1] . Concentrations as low as 2 μg markedly altered morphology and phagocytic activity of polymorphonuclears and macrophages. This toxic effect was partially inhibited by cysteine HCl.[27]

PHYTOTOXICITY Dilution of 1:20,000 toxic to wheat embryo [24] ; highly toxic to various plant cells in concentrations >1:200,000; inhibited growth of maize roots at 1:1,000,000.[26] Concentration of 60 μg/ml lethal to tomato plants [30] .

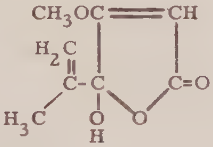
236. PENICILLIC ACID

SOURCE A variety of Penicillium spp and Aspergillus spp [1,2,5-7] ; by synthesis [3] .

NATURE Monobasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_8H_{10}O_4$ [1,2] ; 169-172 (found); 170 (calc.).[1]

STRUCTURE



[4]

CRYSTAL FORM AND COLOR Large, colorless rhombic or hexagonal plates [1] .

MELTING POINT (°C) Hydrate 64-65 [1] . Anhydrous: 86-87.[3]

OPTICAL ACTIVITY Inactive [1] .

SOLUBILITY s. hot water, alcohol, ether, benzene, chloroform; i. petroleum ether.[1]

STABILITY Stable [2] .

OTHER REACTIONS No color with $FeCl_3$ in cold, orange-brown when heated; reddish-purple with strong ammonia on standing; no color with concentrated H_2SO_4, $NaNO_2$, Fearon's nitrochromic acid reagent; negative 2,4-dinitrophenylhydrazine; gives iodoform reaction with hypoiodite solution.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus; Escherichia coli.[2]

BIOLOGICAL ACTIVITY In vitro. Inhibits E. coli in dilution of 1:500,000; Shigella dysenteriae, Proteus vulgaris, Vibrio comma, M. pyogenes var. aureus, Bacillus anthracis, 1:50,000-1:100,000; Salmonella enteritidis, S. paratyphi, S. typhimurium, S. typhosa, 1:33,000. M. citreus, Streptococcus viridans not sensitive to 1:2000.[2] Plant pathogens: Xanthomonas malvacearum, X. campestris, 1:280,000-1:320,000; Erwinia carotovora, 1:160,000. Phytopathogenic fungi: Pythium ultimum, 1:5000; Alternaria citri, Botrytis cinerea, Myrothecium roridum not sensitive to 1:5000.[8]

236. PENICILLIC ACID (Concluded)

TOXICITY LD$_{50}$ in mice, 110 mg/kg, s.c.; 250 mg/kg, i.v.; 600 mg/kg, oral. In rats, antibiotic had antidiuretic effect, and weak digitalis-like action on heart.[9] 1:2000 free acid (but not 1:1000 neutral salt) lethal to tadpoles [5] .

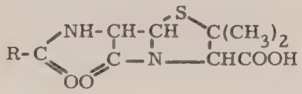
237. PENICILLINS

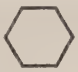
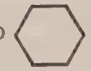
SOURCE Penicillium notatum (Westling) [1] ; Penicillium spp, Aspergillus spp.

NATURE Strong monobasic carboxylic acids.

MOLECULAR FORMULA AND WEIGHT F = $C_{14}H_{20}O_4N_2S$.
G = $C_{16}H_{18}O_4N_2S$.
K = $C_{16}H_{26}O_4N_2S$.
X = $C_{16}H_{18}O_5N_2S$.
331 (found); 333 (calc. -ion only).

STRUCTURE



F: R = CH_3-CH_2CH=CH-CH_2- G: R =  CH_2- K: R = $CH_3(CH_2)_6$- X: R = HO  CH_2-

CRYSTAL FORM AND COLOR Colorless prisms.

MELTING POINT (°C) Penicillin F, Na salt: 204-205 (d.).
G, Na salt: 215 (d.).
X, Na salt: 228-235 (d.).

OPTICAL ACTIVITY Penicillin F: $[\alpha]^{20-25}_D = +276^\circ$ to 316°[1].
G: $[\alpha]^{25}_D = +305^\circ$[1], $+301^\circ$[2].
K: $[\alpha]^{25}_D = +258^\circ$[3].
X: $[\alpha]_D = +267^\circ$[4].

UV ABSORPTION MAXIMA Penicillin G: 252, 257.5, 264 mμ.
F, K: no characteristic bands.
X: 278 mμ.
V: 268, 274 mμ [5]; 270, 276 mμ [6].[5]

SOLUBILITY Acids: s. alcohols, ketones, ethers, esters, aromatic hydrocarbons; sl. s. water; i. aliphatic hydrocarbons. Na salts: s. water, methanol, ethanol; sl. s. dry butanol, ketones, ethyl acetate.

STABILITY Stable in aqueous solution when pure, unstable when impure; labile to acids, alkalies, heat, penicillinase. Penicillin V: More stable at acid pH than G [5] .

OTHER REACTIONS Free acids hygroscopic, rapidly inactivated unless completely dry; inactivated by heavy metals; precipitated from solution by aliphatic hydrocarbons; Na salts inactivated in glacial acetic acid, primary alcohols.

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus. Colorimetric [2] . Iodometric [3, 6] . Penicillinase [4] . Penicillin V: inactivation at pH 2[7] [6] .

BIOLOGICAL ACTIVITY In vitro. In general, penicillin is highly active against Gram-positive bacteria. Although resistant strains are occasionally encountered, most strains of the following genera are sensitive to very low concentrations: Streptococcus, Micrococcus, Diplococcus, Clostridium, Corynebacterium, Bacillus; also Actinomyces. Species of Treponema, Borrelia, and Leptospira are highly sensitive. Strains of Hemophilus and Neisseria are sensitive, but the majority of strains of other Gram-negative bacteria are not: Aerobacter, Escherichia, Klebsiella, Pasteurella, Proteus, Pseudomonas, Salmonella, Shigella and Vibrio spp. Inactive against Mycobacterium spp, pleuropneumonia-like organisms, yeasts, fungi, viruses, rickettsiae, and protozoa. A growing increase in penicillin-resistant strains of M. pyogenes isolated from hospital patients and personnel; recent surveys indicate the incidence of these resistant strains may be well over 50% of the total isolates.

/1/ c, 0.821 water. /2/ c, 2 water. /3/ c, 0.43 water. /4/ c, 0.525 water. /5/ Water. /6/ Chloroform. /7/ To differentiate V from G, using Bacillus subtilis as test organism.

In vivo. Activity in experimental infections in general follows the in vitro antimicrobial spectrum.

CLINICAL For systemic treatment, penicillin is administered almost entirely by i.m. injection, or, much more rarely, by the oral route. Other methods are seldom used. For highly sensitive organisms, systemic therapy by spray inhalation is practicable. When employed orally, much larger doses are generally administered (usually 5-6 times the average i.m. dose) in view of destruction in the digestive tract as well as incomplete absorption. Oral medication is generally regarded as an uncertain therapeutic procedure except when administered in the form of the complex salt, benzathine penicillin G. Penicillin is indicated in a wide variety of infections caused by susceptible organisms. It is also of established value in veterinary practice. (See general references for detailed information on Penicillin F, G, K, O, V, X.)

TOXICITY Crystalline penicillin G is essentially non-toxic in animals, with the exception of guinea pigs. Guinea pigs are peculiarly sensitive to penicillin (and certain other antibiotics); doses as small as 7000 units/kg may produce anorexia, cachexia and finally death within a few days. Doses as high as 9,800,000 units, or 5.93 g/kg, i.v., were tolerated in mice.

In man, tremendous doses of penicillin G are tolerated. One report describes an average daily dose of >86,000,000 units for a 28-day period in an individual, without obvious untoward reactions. Although penicillin G does not produce organic injury, it has considerable capacity in producing sensitization. Sensitivity reactions, varying from mild erythema or hives to severe serum sickness, dermatitis exfoliativa, and even fatal anaphylactic shock, have been reported. Topical application is seldom recommended because this method is most likely to produce sensitization. Penicillin O (allylmercaptomethyl penicillin) is clinically as effective as G and less likely to cause sensitivity or allergic reactions after i.m. injection. Approximately 90% of patients sensitive to G will tolerate penicillin O.

RESISTANCE Development of resistance against penicillin has taken on proportions of a serious clinical problem with Micrococcus pyogenes only. The clinically isolated resistant strains are generally penicillinase producers, in contrast to the resistance induced in vitro by repeated exposure to the antibiotic which is temporary and not associated with penicillinase production.

ABSORPTION AND EXCRETION Penicillin does not enter into brain, nerve, bone and certain other tissues in appreciable amounts. When renal function is normal, approximately 90-100% of crystalline penicillin G appears in the urine a few hours after i.m. administration; approximately 40-70% of this is biologically active and the remainder inactive metabolites. It is also excreted in the bile, with small amounts in the feces and little or none in the saliva, milk, sweat or tears. The rapid urinary excretion has necessitated frequent doses of penicillin G in order to maintain effective blood levels. Methods developed for decreasing this excretion rate include the use of p-aminobenzoic acid, p-aminohippuric acid, carinamide, probenecid and other agents. More widely used method for obtaining sustained blood and urine concentrations has been the injection of small particulate procaine G; because of its low solubility following i.m. administration, detectable concentrations are usually found for 8-12 hours in the blood and as long as 72 hours in the urine. Benzathine penicillin (N, N'-dibenzylethylenediamine dipenicillin G), a recently developed complex salt of penicillin, is very poorly soluble and produces therapeutic blood concentrations which are sustained for as long as 3 weeks after a single i.m. injection. Because of its limited solubility in the stomach, it is not highly susceptible to destruction by gastric juices. When administered orally in adequate doses of 6-8 hour intervals, it provides effective blood levels. Another recently developed ester, penicillin penethamate hydriodide (diethylaminoethyl ester penicillin G hydriodide), following i.m. administration produces fairly high tissue concentrations in the lung and lymph tissues; also gives higher cerebrospinal fluid concentrations than other penicillins. The recently developed penicillin V (phenoxymethylpenicillin) after oral administration produces blood concentrations considerably higher than those obtained with comparable doses of penicillin G, and twice as much penicillin V as penicillin G is excreted in active form. The higher blood levels obtained with product V are attributed to its greater stability than G under acid conditions.[7]

MODE OF ACTION Bacteriostatic and slowly bactericidial. Penicillin inhibits assimilation of glutamic acid and other amino acids by bacterial cells; has been postulated that it interferes with nucleic acid metabolism.

238. PHAEOFACIN

SOURCE Streptomyces phaeofaciens [1] .

SOLUBILITY s. ethyl acetate, ethanol, acetone, benzol; sl. s. ether, petroleum ether; i. water.[1]

OTHER REACTIONS Positive $FeCl_3$; negative biuret, Millon, ninhydrin, Molisch, Tollens, Sakaguchi.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi: Trichophyton spp, Histoplasma capsulatum, Cryptococcus neoformans, Achorion gypseum, Torula utilis, Penicillium chrysogenum, Trichosporon beigelli, 0.7-6.0 μg/ml. Nocardia asteroides also sensitive. No activity against bacteria.[1,2]

TOXICITY LD_{100} in mice, approximately 200 mg/kg, i.p. [1,2] .

239. PHAGOLESSIN A-58

SOURCE Streptomyces griseus [1] .

FORM AND COLOR Light yellow, amorphous, hygroscopic powder [1] .

SOLUBILITY s. water, methanol, ethanol; i. acetone, ether, benzene, chloroform, petroleum ether.[1]

STABILITY Thermostable at pH 3, less so above [1] .

OTHER REACTIONS Negative $FeCl_3$, biuret, Millon, ninhydrin, Lassaigne's nitrogen; reacts with picric acid, Reinecke's salt, methyl orange.[1]

QUANTITATIVE DETERMINATION Microbiological: Choleraphage C [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Klebsiella pneumoniae, 3; Micrococcus pyogenes var. aureus, Escherichia coli, 12.5; Bacillus subtilis, 25; Mycobacterium smegmatis, 50; B. mycoides, Pseudomonas aeruginosa, >1000. High activity against bacteriophages: 37 out of 59 (including phage C of Vibrio comma, Ps. aeruginosa phage 2A, and phage of Streptomyces griseus) inactivated within 15 minutes by concentrations of 10 units/ml.[1] Active in vitro against viruses of vaccinia, herpes simplex, rabies; slight activity against Theiler and Lansing strains of poliomyelitis; no activity against viruses of lymphogranuloma venereum and influenza (PR-8 strain).[3] Concentration of 5 mg/ml inhibited Y-SK poliomyelitis virus in tissue cultures; also inhibited influenza A virus in chick embryo.[2] Spirochetes and protozoa: Borrelia duttoni, Plasmodium berghei, Trypanosoma equiperdum sensitive in vitro [3] .

TOXICITY LD_{100} in mice, 31 mg/kg, i.p.; 500 mg/kg, s.c.[1] Toxic when tested in mice infected with poliomyelitis or swine influenza virus [2] .

240. PHALAMYCIN

SOURCE A variant of Streptomyces noursei [1] .

NATURE Neutral [1] .

FORM AND COLOR Yellow amorphous powder [1] .

SOLUBILITY s. lower aliphatic alcohols, esters, chloroform, acetone; sl. s. benzene, water.[1]

STABILITY Stable at pH 2.5-7 [1] .

OTHER REACTIONS Negative biuret, ninhydrin, Sakaguchi, Molisch, Millon, $FeCl_3$; slight reduction of Benedict's solution; decolorizes Br water and $KMnO_4$; produces small amount of Prussian blue with Palet's reagent; slight UV inflection between 2930 and 3160 Å.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Diplococcus pneumoniae, <0.4-0.8; Micrococcus pyogenes var. aureus, Streptococcus spp, 0.8-8.9; Corynebacterium spp, <0.4-4.4; Bacillus subtilis, Mycobacterium tuberculosis, Sarcina lutea, 0.8; B. anthracis, 16. Nocardia sp sensitive to 6 μg/ml.[1]

In vivo. Crude preparations gave protection against Str. pyogenes in mice.[1]

TOXICITY LD_0 in mice, >116 mg/kg, s.c.; >30 mg/kg, i.p.[1]

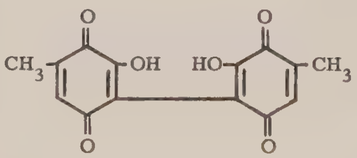
241. PHENICIN
(Phoenicin)

SOURCE Penicillium phoeniceum [1] ; P. rubrum [4] .

NATURE Dibasic acid pigment [2] .

MOLECULAR FORMULA $C_{14}H_{10}O_6$ [1-3] .

STRUCTURE



[3]

CRYSTAL FORM AND COLOR Long, rectangular, yellow-brown tablets [1, 2] .

241. PHENICIN (Concluded)

MELTING POINT (°C) 229-231 [1, 2] .

SOLUBILITY s. chloroform, acetic acid, warm ethanol; sl. s. water.[1, 2]

OTHER REACTIONS Yellow, red or violet color depending on pH; intense violet color in alcoholic solution in presence of $FeCl_3$; released I from KI; decolorized by sodium hydrosulfite.[1, 2] Closely related to fumigatin and spinulosin [4] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Corynebacterium xerose, Micrococcus pyogenes var. aureus, Mycobacterium phlei [1] .

242. PHTHIOCOL

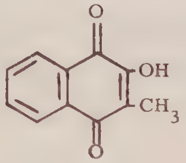
(3-Hydroxy-2-methyl-1, 4-naphthoquinone)

SOURCE Mycobacterium tuberculosis [2] .

NATURE Pigment [1] .

MOLECULAR FORMULA $C_{11}H_8O_3$ [1] .

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Bright yellow prisms [1] .

MELTING POINT (°C) 173-175 [1] .

SOLUBILITY s. organic solvents; i. water, petroleum ether. Salts: s. water, alcohol, acetone.[1]

OTHER REACTIONS An isomer of plumbagin; volatile with steam; deep red salts with alkalies and strong bases; intense red solutions in alkali or bicarbonate.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Streptococcus pyogenes, Diplococcus pneumoniae, Bacillus anthracis in dilution of 1:5000; Micrococcus pyogenes var. aureus, Str. salivarius, Corynebacterium diphtheriae, Escherichia coli, Shigella paradysenteriae, 1:2000; Salmonella typhosa, Neisseria catarrhalis, 1:1000.[2]

243. PHTHIOMYCIN

SOURCE Streptomyces luteochromogenes, n. sp [1] .

FORM AND COLOR White amorphous powder [1] .

UV ABSORPTION MAXIMA 268 mμ[1]; 282 mμ[2].[1, 2]

OTHER REACTIONS Resembles viomycin; positive Sakaguchi, ninhydrin, negative Molisch, maltol, $FeCl_3$.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis, 10->50; Myco. phlei, 6-10; Myco. smegmatis, 10; Mycobacterium spp, Bacillus anthracis, B. subtilis, 25.[1, 2]

In vivo. Daily s.c. doses of 2-6 mg for 29 days reduced morbidity in mice infected with Myco. tuberculosis [2] .

TOXICITY LD_{50} in mice, 505-600 mg/kg, i.v. [1, 2] .

244. PICROMYCIN

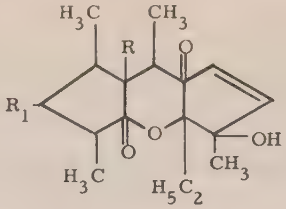
SOURCE Streptomyces felleus, n. sp [1] .

NATURE Basic [2, 3] .

MOLECULAR FORMULA AND WEIGHT $C_{25}H_{43}O_7N$ [1-3] ; 458 (Rast); 469 (calc.).[1, 3]

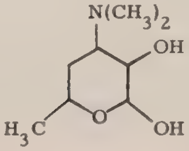
/1/ 0.1 N HCl. /2/ 0.1 N NaOH.

STRUCTURE



R = desosamine group; R1 = H
or R1 = " " ; R = H

Desosamine:



[8]

CRYSTAL FORM AND COLOR Colorless; "coffin-cover shaped" [1,3] ; needles [8] .

MELTING POINT (°C) 169-170 [1,3] ; 160-162[1] [8] .

OPTICAL ACTIVITY $[\alpha]_D^{24}$ = -50.2°[2], +8.2°[3] [1-3] ; $[\alpha]_D^{20}$ = -33.5°[4] [8] .

UV ABSORPTION 225 mμ [8] .

SOLUBILITY s. most organic solvents, dilute acids; sl. s. water, petroleum ether, carbon disulfide, alkali.[1,3]

STABILITY Thermolabile in dilute acid, alkali; thermostable in vacuo.[1,2]

OTHER REACTIONS Bitter taste; negative ninhydrin, p-nitrophenylhydrazine, semicarbazide; forms amorphous picrate and picrolonate; dissolves in concentrated HCl to produce orange-red color that fades when diluted, forming flocculent precipitate; no methoxy groups present; negative Abderhalden reaction with ninhydrin after boiling with HCl; insoluble inactive degradation product obtained after heating the HCl at pH 8 for 12-14 hours at 60°C. Infrared: 2.93, 3.47, 3.54, 3.65, 5.74, 5.91, 6.12, 6.89, 7.28, 7.48, 7.61, 7.87, 8.41, 8.62, 9.07, 9.19, 9.31, 9.34, 9.44, 9.57, 9.78 μ.[1-3] Mild hydrolysis yields picrocin, $C_8H_{17}O_3N_2$, and chromycin, $C_{16}H_{24}O_4$, the lactone of an α-keto acid [7] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Streptococcus pyogenes, Str. agalactiae, Str. faecalis, Diplococcus pneumoniae, Corynebacterium pyogenes, Clostridium spp, Mycobacterium tuberculosis, Bacillus anthracis, B. subtilis, Micrococcus pyogenes var. aureus, Pasteurella multocida, 0.1-3.0; Escherichia coli, Aerobacter aerogenes, Pseudomonas aeruginosa, Klebsiella pneumoniae, Salmonella spp, and fungi, 200-1000.[1,4] Inhibits B. subtilis, 1:3,000,000 dilution; Myco. tuberculosis, 1:20,000; E. coli, 1:2000.[5] In vitro resistance not readily acquired after 10 passages in antibiotic-containing media [4] .

In vivo. No activity against Str. pyogenes, M. pyogenes var. aureus, D. pneumoniae; mouse pneumonitis virus in mice treated by s.c. or oral routes.[4]

CLINICAL Successfully used in topical application for skin infections in 170 cases [6] .

TOXICITY LD_{100} in mice, 100 mg/kg, s.c.; 250 mg/kg, oral.[4] 150 mg/kg, i.v., lethal [1] .

245. PLEOCIDIN

SOURCE Streptomyces sp resembling S. lavendulae [1] .

FORM AND COLOR White hygroscopic powder [1] .

SOLUBILITY s. water, methanol, ethanol [1] .

STABILITY Most stable in aqueous solution at pH 4-6 [1] .

OTHER REACTIONS Resembles streptothricin [1] .

/1/ A sample crystallized four times from ethyl acetate had a melting point of 169.5-170. /2/ c, 6.3 chloroform. /3/ c, 3.5 ethanol. /4/ c, 2.071 chloroform.

245. PLEOCIDIN (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Proteus vulgaris [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, Mycobacterium tuberculosis, Salmonella typhosa, 0.9; Micrococcus pyogenes var. aureus, Klebsiella pneumoniae, 1.9; Pseudomonas aeruginosa, 31.2; Escherichia coli, 62.5. Inhibits Saccharomyces cerevisiae, Aspergillus niger, 0.9.[1]

In vivo. No activity in mice infected with Trypanosoma cruzi [3] .

PHYTOPATHOLOGY Low concentrations inhibited growth of Tilletia caries (wheat smut fungus) in vitro [4] . The antibiotic was readily absorbed by leaves of tobacco, tomato, and bean plants when applied as spray. Was transported down out of intermediate treated leaves and up stem to younger leaves, as well as downward to older untreated leaves. In some instances, translocation to roots occurred. The antibiotic caused injury to treated leaves in the form of necrotic spots.[5]

TOXICITY Highly toxic to mice. LD_{50}, 3 mg/kg, i.p.; approximately 120 mg/kg, oral. Repeated topical application irritating to rabbit eye.[1]

246. PLEOMYCIN

SOURCE Streptomyces pleofaciens, n. sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{14}H_{12}O_8$; 303 (found).[1]

CRYSTAL FORM AND COLOR Acid form: glistening, colorless rectangular plates [1] .

MELTING POINT (°C) Acid form: 235 (uncorr.) [1] .

UV ABSORPTION MAXIMA 270, 330-340 mμ[1] [1] .

SOLUBILITY s. methanol, ethanol, ethyl acetate, ether, benzene. Alkaline salts: s. water.[1]

OTHER REACTIONS Sublimes at 200°C or lower in vacuo, but retains biological activity; C, 54.63; H, 3.94; O, 41.43. Infrared: 2.90, 3.23, 3.43, 3.54, 6.29, 6.59, 6.85, 7.08, 7.28, 7.44, 7.80, 7.88, 8.20, 8.48, 8.60, 9.60, 10.16, 12.24, 12.62, 13.80, 15.07 μ.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, Micrococcus pyogenes var. aureus, Escherichia coli, Proteus vulgaris, Salmonella typhosa, Pseudomonas aeruginosa, 6.25; Mycobacterium tuberculosis, 10-12.5. Aspergillus niger inhibited by 100 μg/ml.[1]

TOXICITY LD_{50} in mice, 35 mg/kg, i.p. Topical application of 1 mg/ml solution induced corneal opacity in rabbit eye.[1]

247. PLEUROMUTILIN
(Drosophilin B)

SOURCE Pleurotus mutilus [2] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{34}O_5$ [1, 2] ; 310 (found); 378 (calc.).[2]

CRYSTAL FORM AND COLOR White crystals [2] .

MELTING POINT (°C) 170-171 [1] .

OPTICAL ACTIVITY $[\alpha]_D^{24} = +20°$[2] [1] .

UV ABSORPTION MAXIMA 290 mμ; end absorption below 230 mμ. [1, 2]

SOLUBILITY s. alcohol, acetone, chloroform, ether; sl. s. water; i. hexane.[2]

STABILITY Relatively stable [2] .

OTHER REACTIONS Reduces Tollens; no reduction of ammoniacal $AgNO_3$.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Klebsiella pneumoniae, Mycobacterium smegmatis, Diplococcus pneumoniae, Streptococcus pyogenes, Micrococcus pyogenes var. aureus, Bacillus subtillis, 0.5-16.0; B. mycoides, Escherichia coli, Pseudomonas aeruginosa, 125-500. Fungi not sensitive.[3] Active against influenza (PR-8) virus at 2 mg/ml, but inactive in chick embryo. No activity against poliomyelitis virus.[4]

/1/ In 0.13 M phosphate buffer. /2/ c, 3 absolute methanol.

In vivo. No activity in mice infected with Str. pyogenes; no suppression in development of sarcoma 180 in mice.[2] Daily i.p. doses of 80 mg/kg were ineffective against Plasmodium gallinaceum in chicks [5] .

TOXICITY LD_0 in mice, 50 mg/kg, i.v. and i.p. [3] .

248. PLEUROTIN

SOURCE Pleurotus griseus [1] .

NATURE Neutral compound [1] .

MOLECULAR FORMULA AND WEIGHT $C_{20}H_{22}O_5$; 343 (Rast); 342.4 (calc.).[1]

CRYSTAL FORM AND COLOR Orange, amber, yellow needles [1] .

MELTING POINT (°C) 200-215 (d.) [1].

OPTICAL ACTIVITY $[\alpha]_D^{23} = -20^{\circ}$[1] [1] .

UV ABSORPTION MAXIMUM 250 mμ [1] .

SOLUBILITY s. acetone; less s. water, ethanol, ether, chloroform; i. or sl. s. dilute acids, dilute sodium carbonate, petroleum ether.[1]

STABILITY Thermolabile, especially at alkaline pH [1] .

OTHER REACTION Inactivated by light; negative $FeCl_3$; I liberated from acidified KI; blue color with KCN.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] . Colorimetric [1, 2] . Fluorometric [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, 0.2; M. pyogenes var. aureus, 0.8; B. mycoides, 1.6-3.0; Photobacterium fischeri, 6; Mycobacterium smegmatis, 32; Myco. phlei, >32; Myco. tuberculosis, >100; Escherichia coli, Klebsiella pneumoniae, 500->500.[1, 2]

In vivo. Daily i.p. doses of 100 mg/kg gave no protection in chicks infected with Plasmodium gallinaceum [4] .

TOXICITY Mice tolerated 24 mg/kg, i.v.; low solubility did not permit higher doses.[1]

249. POLYMYXINS

The trademark of Burroughs Wellcome & Co., Inc., for polymyxin B is Aerosporin.

SOURCE Various strains of Bacillus polymyxa [1, 9, 10] .

NATURE Basic polypeptides [2] .

MOLECULAR FORMULA AND WEIGHT Polymyxin $B_1 \cdot 5HCl$: $C_{56}H_{104}O_{14}N_{16}Cl_5$; 1150 ± 10% (found).[7]
D·4HCl: $C_{50}H_{97}O_{15}N_{15}Cl_4$ (proposed); 1150 (found); 1144 (calc.).[5]
A, B, D, E: Average MW, 1250 (found) [8] .

CRYSTAL FORM Birefringent; no definite structure [3] .

MELTING POINT (°C) 228-235 (d.) [4, 5] .

OPTICAL ACTIVITY Polymyxin A HCl: $[\alpha]_D^{20} = -42^{\circ}$[2] [4] .
B HCl: $[\alpha]_D^{25} = -75.7^{\circ}$[3] [6] ; $[\alpha]_D^{23} = -40^{\circ}$[4] [5] .
$B_1 \cdot 5HCl$: $[\alpha]_D^{25} = -85.1^{\circ}$[5] [7] .

UV ABSORPTION MAXIMA None characteristic [4] .

SOLUBILITY s. water, methanol; less s. higher alcohols; i. ether, esters, hydrocarbons, chlorinated solvents. Base: sl. s. water; i. alcohol.[4, 5]

STABILITY Thermo- and acid stable; alkali unstable.[4]

/1/ c, 0.59 chloroform. /2/ Water. /3/ c, 1 in 75% ethanol. /4/ c, 1.05 water. /5/ c, 2.33 in 75% ethanol.

OTHER REACTIONS Amino acid content:

	D-Leucine	Phenylalanine	L-Threonine	D-Serine
Polymyxin A	+	-	+	-
B	+	+	+	-
C	-	+	+	-
D	+	-	+	+

Positive biuret, ninhydrin; negative Molisch, Sakaguchi, Pauly, Hopkins-Cole; precipitate with picric, flavianic, helianthic, Reinecke acids; amorphous materials with acetic, phenylacetic, oxalic, malic, benzoic, phthalic, cinnamic, succinic, naphthalene β-sulfonic acids. Polymyxin B separates by countercurrent distribution into B_1 and B_2; B_1 differs in that it contains isopelargonic acid (both contain α, γ-diaminobutyric acid, and amino acids shown above).[2, 4, 5, 7]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli and other Gram-negative organisms [1, 3, 50, 52]. Precipitation as phosphotungstate [50].

BIOLOGICAL ACTIVITY Active mainly against Gram-negative bacteria. All polymyxins show essentially similar antibacterial spectra. In vitro. The majority of strains of the following are inhibited by concentrations of 0.02-5.0 μg/ml: Aerobacter aerogenes, Alcaligenes spp, Brucella abortus, Br. bronchiseptica, Escherichia coli, Hemophilus influenzae, H. pertussis, Klebsiella pneumoniae, Neisseria catarrhalis, N. meningitidis, Pasteurella multocida, Past. pestis, Pseudomonas aeruginosa, Salmonella typhosa, S. paratyphi, S. schottmuelleri, S. enteritidis, Salmonella spp, Shigella dysenteriae, Sh. paradysenteriae, Sh. sonnei, Vibrio comma. In general, the following require 10-50 μg/ml for inhibition: Clostridium perfringens, Corynebacterium diphtheriae, Bacillus subtilis. Generally resistant, >50 μg/ml: N. gonorrhoeae, Proteus spp, Streptococcus pyogenes, Streptococcus spp, Diplococcus pneumoniae, Micrococcus pyogenes var. aureus, Mycobacterium tuberculosis.[11-19] Bovine strains of Cryptococcus neoformans sensitive to 25 μg/ml [53]. Little or no activity against fungi, but polymyxins B and E in high concentration (125-250 μg/ml) inhibited Trichophyton mentagrophytes, T. purpureum, Microsporum audouini, M. lanosum, Candida albicans; products A and D less active.[20] Polymyxin B inhibited Trichomonas vaginalis at 125 μg/ml [30].

In vivo. Polymyxins A, B, and D administered i.p. or s.c. gave good protection in mice infected with S. typhosa, H. pertussis, K. pneumoniae, and in chicks infected with Past. multocida and S. gallinarum.[3, 11, 13, 21, 24] A, B, C, D and E were all equally effective against S. typhosa, but against H. pertussis product D was less active [23]. Good protection in experimental plague (Past. pestis) and against H. influenzae in mice [34, 42]. Polymyxin B effective in experimental corneal ulcer induced with Ps. aeruginosa in rabbits [28]. No protection in mice infected with S. typhimurium, Str. pyogenes, Erysipelothrix rhusiopathiae, Micrococcus pyogenes var. aureus when treated with product A [21]. Polymyxin D ineffective in mouse infections with Past. tularensis and in guinea pigs infected with Br. suis [22]. No activity in Borrelia anserina infection (spirochetosis) in chicks [27], or in mice infected with Trypanosoma cruzi [29].

CLINICAL Early studies indicated that polymyxin D, in i.m. doses of 3-7 mg/kg/da for 3-20 days, gave promising results in Aerobacter aerogenes bacteremia, in pertussis, acute brucellosis, K. pneumoniae infection; evidence of renal toxicity noted.[25] Lower doses of products A and B were beneficial in pertussis and in infections with E. coli and Ps. aeruginosa [26]. The nephrotoxicity and neurotoxicity following i.m. administration has limited their general use in systemic infections. Polymyxin B shows least toxicity, and it is probable that impurities present in various lots may partially account for these effects [31]. Purer preparations of B (and more recently polymyxin E) appear to have been safely used for i.m. injection without evidence of nephrotoxicity and other side effects. Ps. aeruginosa infections (especially those of the urinary tract), which generally do not respond to therapy with other antibiotics, frequently respond to treatment with polymyxin B. The usual i.m. dosage range is 1.5-2.5 mg/kg/da and should not exceed 2.5 mg/kg/da, or in any case 200 mg/da.[32, 33, 36] Subconjunctival administration of polymyxin E has given good clinical response in ocular infections caused by Pseudomonas [35]. Oral therapy is of value in gastrointestinal infections caused by Shigella and Pseudomonas [37], and is highly effective in clearing carriers of Sh. paradysenteriae. No side effects were noted as a result of oral medication.[38] In preliminary trials, favorable results reported in Ps. aeruginosa meningitis following intrathecal injection of polymyxin B in doses of approximately 5 mg/da [39, 40]. For topical use, polymyxin B has been combined with oxytetracycline and other antibiotics, with favorable response in a wide variety of skin infections [31, 41]. The antibiotic is also of value when topically applied in corneal ulcers caused by Ps. aeruginosa [31].

ACUTE TOXICITY Polymyxin A, B, E: LD_{50} in mice, 6-9 mg/kg, i.v.; 13-39 mg/kg, i.p.; 68-87 mg/kg, s.c. [21, 23] Polymyxin D: 12-18 mg/kg, i.v.; 24-77 mg/kg, i.p.; 160-230 mg/kg, s.c.[11, 42] Intracisternal injection of 0.6 mg/kg of A lethal to rabbits [24]. Dogs tolerated D in i.v. doses of 15 mg/kg; 25 mg/kg were lethal [42]. Little or no tissue injury at site of i.m. or s.c. injection of product E, as compared with some local reaction with B [23].

In vitro. In tissue cultures, polymyxin B sulfate partially suppressed growth of chick embryonic heart at concentrations of 300 μg/ml, with complete inhibition at 2500 μg/ml [54]. The antibiotic has a fragmenting action on rat mast cells in vitro which is comparable to that of certain histamine liberators [55].

249. POLYMYXINS (Concluded)

CHRONIC TOXICITY Renal toxicity noted in rats after repeated doses of polymyxin A and D; much less with B, least with E. Some protection against kidney damage in rats and dogs afforded by administration of DL-methionine. [23, 24] The protection afforded by methionine and S-methyl-cysteine against the nephrotoxicity induced by polymyxin A appears to be attributable to a replenishment of the supply of labile methyl groups [56].

In man, polymyxins A and D induced renal damage as evidenced by proteinuria, cylindruria and nitrogen retention; nausea and epigastric distress observed in a few patients [24, 39]. Polymyxin B appears to be fairly well tolerated following i.m. dosages of approximately 2.5 mg/kg/da, with minimal nephrotoxicity or other side effects in patients with normal kidneys [32, 33]. Oral doses are well tolerated [37, 38]. Topical use of dermatological preparations of polymyxin B is associated with a low index of skin sensitization, in contrast to penicillin, streptomycin, and the sulfonamides [57].

RESISTANCE In vitro resistance did not readily develop with strains of E. coli, K. pneumoniae, and S. pullorum [3, 11]. Development of resistance to polymyxin B is dependent upon the amino acid content of the culture medium [48].

ABSORPTION AND EXCRETION Polymyxins A, B, E were not absorbed in significant amount after oral administration. Following i.m. dosages in man or animals, measurable blood concentrations were maintained for 3-16 hours. Polymyxin A produced higher levels than B or E. After single parenteral injection, only a small fraction of the dose was excreted in the urine and none was detected in the bile.[23] No polymyxin D detectable in cerebrospinal fluid after i.v. or i.m. injection in dogs, or following i.m. administration in man [25, 39]. Serum concentrations of 1-8 μg/ml were observed in man after 2-4 mg/kg/da of polymyxin B in divided doses administered i.m., with peak levels ½-2 hours after injections, approximately 0.5-3.0 μg/ml after 6 hours, and detectable concentrations up to 12 hours.[43]

MODE OF ACTION Action essentially bactericidal, e.g., sterilization and partial lysis of cells of E. coli within 20 minutes of exposure [11, 12]. Forms water-insoluble products with ribonucleic acids, mononucleotides, certain phosphoamino lipids and related compounds; this may explain the ability of polymyxin to agglutinate certain bacteria.[44] In low concentration, antibiotic inhibits mycobacterial esterases similar to that observed with quaternary ammonium detergents, hence a detergent-like structure has been postulated [45]. Exposure to polymyxin causes release of soluble constituents from sensitive bacterial cells; has been suggested that polymyxin disorganizes structures within cell wall which maintain osmotic equilibrium.[46, 47] In vitro activity of polymyxins antagonized by magnesium ribonucleate, hence it has been suggested that presence of this substance in Gram-positive organisms may be a factor contributing to the selective action of this antibiotic [58]. Inhibition of Ps. aeruginosa was reversed when Mg^{++}, Mn^{++}, Ca^{++}, and $Fe^{++(+)}$ were added to the culture medium [59].

MISCELLANEOUS S.c. injection of polymyxin B or E in rats released skin histamine remote from the site of inoculation; when injected i.v. in dogs and cats this effect was much less marked.[51] Relatively high levels (300-500 mg per 14 lb of wheat) of polymyxin B and certain other antibiotics were lethal to several varieties of coleopterous stored-grain insects within 30-60 days [60]. Growth of wheat roots in water was stimulated by addition of 0.32-1.0 ppm of product B [61]. Root growth of young seedlings of barley and other species inhibited by immersion in solutions containing 5-100 ppm of this antibiotic; this inhibition was suppressed by an excess of calcium, probably by preventing absorption of the antibiotic.[62] Highly effective for control of microbial contamination in brewing industry [49].

250. POLYPEPTIN

Formerly named Circulin

SOURCE Bacillus krzemieniewski, a variant of B. circulans [4].

NATURE Basic polypeptide [1, 2].

MOLECULAR FORMULA AND WEIGHT $C_{56}H_{96}O_{13}N_{12}$ (proposed); 1100-1200 (found); 1145 (calc.).[3]

CRYSTAL FORM Triangular prisms[1] [1, 2].

MELTING POINT (°C) Sulfate: 235 (d.). Acetate: 160. Base: 176.[2]

OPTICAL ACTIVITY Sulfate: $[\alpha]_D^{20} = -93.3^\circ$ [1, 2].

UV ABSORPTION MAXIMA 252, 258, 264 mμ [1, 2].

SOLUBILITY Sulfate: s. ethylene glycol, pyridine, glacial acetic acid, allyl alcohol, phenol; briefly s. methanol, ethanol; i. anhydrous acetone, ether, chloroform, amyl acetate, benzene, carbon disulfide, petroleum ether.[2]

STABILITY Thermostable; less so in alkaline solution; base stable when dry.[1, 2]

/1/ From 65% ethanol; crystal form varies with solvents.

250. POLYPEPTIN (Concluded)

OTHER REACTIONS Positive biuret, ninhydrin; dialyzable; not inactivated by pepsin, trypsin, H_2S, $FeCl_3$; precipitated from water by dilute solution of I in KI; base precipitates in methanol; crystalline sulfate found to be 2 basic polypeptides with identical amino acid spectra (residues isolated: 3 L-α-γ-diaminobutyric acid, 1 L-threonine, 1 D-valine, 1 L-isoleucine; 2 L-leucine; 1 D-phenylalanine plus an unknown acid).[2, 3]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, 0.75; Diplococcus pneumoniae, Streptococcus pyogenes, Clostridium histolyticum, Shigella dysenteriae, 1.5; Klebsiella pneumoniae, 1.5-3.0; E. coli, Salmonella typhosa, S. paratyphi, S. schottmuelleri, B. mycoides, Cl. perfringens, Cl. fallax, 3; Mycobacterium tuberculosis, S. typhimurium, 4.5; Pseudomonas aeruginosa, 10. Fungi: Epidermophyton floccosum, Blastomyces dermatitidis, Sporotrichum schenckii, Histoplasma capsulatum, Microsporum audouini, 1.5; Trichophyton rubrum, Candida albicans, 3.[4]

TOXICITY LD_{50} in mice, 15 mg/kg, i.p. In vitro. Hemolytic for red blood cells.[4]

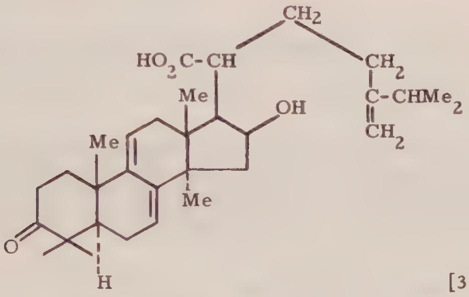
251. POLYPORENIC ACID C

SOURCE Polyporus betulina [1] .

NATURE Triterpenoid acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_{31}H_{46}O_4$ [3] ; 480 (equiv. wt. found).[1]

STRUCTURE



[3, 4]

CRYSTAL FORM Microcrystalline aggregates [1] .

MELTING POINT (°C) 285-290 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]_{5461}^{20}$ = +8.19°[1] [1] .

SOLUBILITY s. pyridine, ethanol, hot glacial acetic acid, dioxane, chloroform, nitrobenzene; sl. s. acetone, ethyl acetate.[1]

OTHER REACTIONS Blue-violet with acetic anhydride and H_2SO_4; orange lower layer with chloroform and H_2SO_4.[1]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium spp [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Myco. phlei, Myco. smegmatis in dilution of 1:640,000-1:1,280,000. Slight activity against Micrococcus pyogenes var. aureus and Escherichia coli.[2]

252. POLYPORIN

SOURCE Polystictus sanguineus [1] .

NATURE Acidic [1] .

SOLUBILITY s. dry ether, chloroform, ethyl acetate, absolute alcohol, acetone [1] .

STABILITY Thermostable except in alkali and acid [1] .

/1/ c, 5.1 pyridine.

252. POLYPORIN (Concluded)

OTHER REACTIONS Non-volatile; unaffected by pepsin, gastric juice [1] .

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli, Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, Streptococcus pyogenes, Str. viridans, Salmonella typhosa, S. paratyphi, S. schottmuelleri, Shigella paradysenteriae, E. coli, Vibrio comma. Virulent cultures of S. typhosa and V. comma following exposure to polyporin were rendered non-infective for guinea pigs.[1]

TOXICITY Non-toxic to guinea pigs and rabbits. Non-pyrogenic when administered i.m. in humans. In vitro. No hemolysis of red blood cells.[1]

CLINICAL Appeared beneficial in typhoid and other Salmonella infections and in cholera following oral doses of 3 ml every 4 hours for 7-10 days. Topical use gave good response in skin and ocular infections caused by micrococci and streptococci.[1, 2]

253. PRIMYCIN

SOURCE An unidentified actinomycete [1] .

MOLECULAR FORMULA AND WEIGHT $C_{19}H_{37}O_7N$ (proposed); 329.9 (ebull. in methanol); 391.5 (calc.).[1]

CRYSTAL FORM AND COLOR White microcrystals[1] [1] .

MELTING POINT (°C) 166-168 (d.) [1] .

UV ABSORPTION MAXIMA None characteristic [1] .

SOLUBILITY s. methanol; less s. higher alcohols; sl. s. pyridine, glacial acetic acid, water; i. other solvents.[1]

STABILITY Thermostable [1] .

OTHER REACTIONS C, 58.79; H, 9.56; N, 3.63, 3.58; aqueous solution sensitive to electrolytes; strongly surface active and adsorptive; first a yellow than a red color in concentrated H_2SO_4; no reduction of Fehling; no reaction with aldehyde reagents; positive Brunner-Pettenkoffer reaction; can be acetylated in pyridine, the product being inactive, but can be reactivated by splitting off acyl groups; partially inactivated by serum; more active in alkali than in acid, optimum pH 7.6-7.8.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus at 0.02-0.06 μg/ml. Also active against other Gram-positive bacteria, including Mycobacterium spp. In vitro activity reduced by approximately 1/4 in presence of serum.[1]

TOXICITY LD_{100} in mice (route not stated), 2.5 mg/kg; in rats, 10 mg/kg. Following i.p. doses of 5 mg/kg in rabbits, detectable levels in serum were noted at 6 hours. In vitro. Non-toxic in tissue cultures [1] .

CLINICAL Used topically with good results in superficial infections [1] .

254. PROACTINOMYCINS

SOURCE Nocardia gardneri [1] .

NATURE Basic [1] .

MOLECULAR FORMULA AND WEIGHT Proactinomycin A: $C_{27}H_{47}O_8N$ (proposed); 445 (Rast).
B: $C_{28}H_{49}O_8N$ (proposed); 513 (Rast).
C: $C_{24}H_{41}O_6N$ (proposed); 322 (Rast).[2]

CRYSTAL FORM Proactinomycin A: short thick plates or prisms.
B: indefinite crystals.
C: amorphous.[2]

MELTING POINT (°C) Proactinomycin A: 168-169. B: 83-87.[2]

UV ABSORPTION MAXIMA Proactinomycin A: approximately 260 mμ[2].
B: approximately 265 mμ[2].
C: approximately 300 mμ[2].

/1/ From methanol-butanol. /2/ Ether.

254. PROACTINOMYCINS (Concluded)

SOLUBILITY Base: s. ether, amyl acetate, benzene, carbon tetrachloride. Salts: s. water.[1]

STABILITY Thermostable at pH 2-7, not at 10.0 [1] .

OTHER REACTIONS Precipitated by picric, picrolonic, Reinecke, flavianic acids [1] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibit (in dilution x 1000) Corynebacterium diphtheriae, 512-2000; Bacillus anthracis, 256-2000; Streptococcus pyogenes, M. pyogenes var. aureus, 160-640; Str. viridans, 256; Diplococcus pneumoniae, 200; Neisseria meningitidis, 800; Salmonella enteritidis, 32-160. Other Gram-negative bacteria, e.g., Salmonella, Proteus, Pseudomonas, Shigella spp, and fungi, not sensitive.[1-3] Proactinomycin B showed slightly lower activity than A and C against bacteria [2] .

PHARMACOLOGY Proactinomycin A: LD$_{100}$ in mice, 100 mg/kg, i.v.; 250-500 mg/kg, i.p.; oral doses of 250 mg/kg well tolerated.[3]

B: LD$_{50}$ in mice, 120 mg/kg. Depressed the blood pressure of decerebrate cats and altered the normal contractions of guinea pig uterus.[2]

C: 80 mg/kg. In mice, oral doses of all three products produced detectable levels in the urine and the gastrointestinal tract, but were not detected in the blood.

In vitro. Decreased motility of human leukocytes.[2]

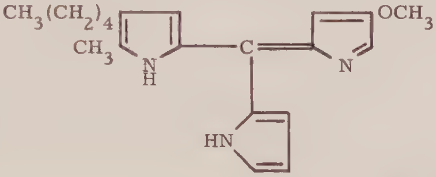
255. PRODIGIOSIN

SOURCE Serratia marcescens [3] .

NATURE Red pigment; monoacidic base.[2, 10]

MOLECULAR FORMULA AND WEIGHT $C_{20}H_{25}ON_3$; 387, 390 (found); 323.2 (calc.).[2, 10]

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Vivid green, metallic leaflets [2] . Base: lustrous, square pyramids, dark red with green reflex [10] .

MELTING POINT (°C) 70-80 (sinters) [2] . Base: 151-152 [10] . Perchlorate: 227-229 [10] .

ABSORPTION MAXIMA 535-540 mμ[1] [1] . Base in ethanol: pH 7.4: 225.5, 288.5, 337, 471, 539 mμ. pH 11: 257, 281, 335.5, 468.5 mμ. pH 2.9: 216, 296, 371, 541 mμ[2].[10]

SOLUBILITY s. alcohol, ether, chloroform, bromoform, benzene; i. water.[2]

STABILITY Thermostable [5] .

OTHER REACTIONS Forms picrate, MP 176°C; salicylate, MP 178°C; benzoate, MP 170°C; perchlorate, MP 228°C (uncorr.).[2] Deep red in acid, orange-yellow in alkaline solution. Infrared: 3270, 3235, 3070, 2895, 2835, 1622, 1578, 1557, 1543, 1458, 1430, 1373, 1360, 1336, 1277, 1253, 1198, 1185, 1144, 1136, 1115, 1078, 1054, 1030, 998, 957, 926, 907, 890, 844, 821, 806, 782, 767, 739, 727 (recip. cm).[10]

BIOLOGICAL ACTIVITY Little or no activity against bacteria; active against certain fungi and protozoa. In vitro. Inhibits protozoa (μg/ml): Entamoeba histolytica, 0.05-15; Trypanosoma cruzi, T. connorhini, Leishmania donovani, L. tropica, 15 or less.[3, 4] E. coli, Dientamoeba fragilis, Endolimax nana sensitive to 40 μg/ml or less [7] . Inhibited growth of the fungus Coccidioides immitis at 2 μg/ml [5] . Little or no antibacterial activity [3] . In vitro antifungal activity reversed by certain unsaturated fatty acids and Tween 80, but not by saturated straight-chain fatty acids [9] .

In vivo. Slight activity in mice infected with Micrococcus pyogenes var. aureus and Diplococcus pneumoniae following i.p. treatment [6] . Oral doses in rodents of 6.5 mg/kg prevented infection with E. histolytica, Trypanosoma brucei and T. equiperdum [3] .

/1/ Acid chloroform. /2/ Inflections at 275.0, 382, 510 mμ.

255. PRODIGIOSIN (Concluded)

CLINICAL Encouraging results in 6 of 9 patients with disseminated coccidioidomycosis treated with oral doses of 10-30 mg/da, or i.v. doses of 10-25 mg/da. No kidney or liver damage noted in these cases.[8]

TOXICITY Mice and guinea pigs tolerated i.p. doses of 1 mg/kg.[3]

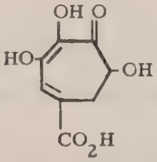
256. PUBERULIC ACID

SOURCE Penicillium puberulum and other Penicillium spp [1, 2] .

NATURE Dibasic acid [1, 2] .

MOLECULAR FORMULA AND WEIGHT $C_8H_6O_6$; 95.4 (equiv. found); 99 (equiv. calc.).[1]

STRUCTURE



[3, 4]

CRYSTAL FORM AND COLOR Microcrystalline plates; colorless [6] .

MELTING POINT (°C) 316-320 (d.) [2, 6] .

UV ABSORPTION MAXIMA 270, 350 mμ [6] .

SOLUBILITY sl. s. water; i. saturated hydrocarbons.[1, 5]

OTHER REACTIONS Yellow-brown color with dilute $FeCl_3$, amethyst to deep red-brown with excess $FeCl_3$; various derivatives among which the diacetyl compound has colorless crystals, MP 212°C; occurs in culture fluids with puberulonic acid.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Bacillus anthracis, M. pyogenes var. aureus in dilution of 1:17,000-1:33,000; Streptococcus pyogenes, 1:6000. Str. viridans, Escherichia coli, Vibrio comma less sensitive.[2]

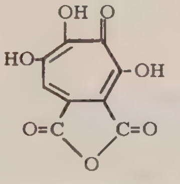
257. PUBERULONIC ACID

SOURCE Same as for puberulic acid [2] .

NATURE Dibasic acid [1] .

MOLECULAR FORMULA AND WEIGHT $C_9H_4O_7$ [4-6] ; 217, 187 (found).[1]

STRUCTURE



[3, 4]

CRYSTAL FORM AND COLOR Yellow plates, prisms or needles[1] [1, 2, 6] .

MELTING POINT (°C) 296-298 (d.) [1, 2] .

UV ABSORPTION MAXIMA 274.5, 317 mμ [6] .

SOLUBILITY s. ether, alcohols; sl. s. water; i. saturated hydrocarbons.[5]

OTHER REACTIONS Can be converted into puberulic acid; $FeCl_3$ reactions same as puberulic acid; no esters or acetyl derivatives [1, 2, 4] .

/1/ Sodium salt: orange needles.

257. PUBERULONIC ACID

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [2] .

BIOLOGICAL ACTIVITY In vitro. Same antibacterial spectrum as puberulic acid, but approximately 1/4 as active [2] .

258. PUMILIN

SOURCE Bacillus pumilus [1] .

NATURE Largely non-peptide [1] .

CRYSTAL FORM AND COLOR Lemon yellow, small hexagonal crystals, average diameter 10 μ[1] [1] .

MELTING POINT (°C) No melting below 360 [1] .

SOLUBILITY s. pyridine, collidine, morpholine; less s. aqueous acetone (1 mg/ml); sl. s. warm methanol, ethanol.[1]

STABILITY Loses activity in UV light and sunlight, more slowly in diffuse light; inactivated slowly in nutrient broth at 37°C.[1]

OTHER REACTIONS Fluoresces strongly in solution in UV; no diffusion through agar; dissolves in N/20 NaOH without losing activity; infrared shows hydroxyl group; no color with $FeCl_3$; irreversible change to copper-red with slight decrease in activity in 5N HCl at room temperature; activity antagonized by horse serum; unaffected by cysteine.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (in dilution x 10^6) Micrococcus pyogenes var. aureus, Streptococcus pyogenes, 400-500; Str. faecalis, 50-125; Pasteurella multocida, 20.[1]
In vivo. No activity when administered i.p. or s.c. in mice infected with Str. pyogenes [1] .

ACUTE TOXICITY I.p. doses of 0.75 mg/kg lethal to mice; 50 mg/kg, s.c., tolerated.[1]

259. PUROMYCIN[2]

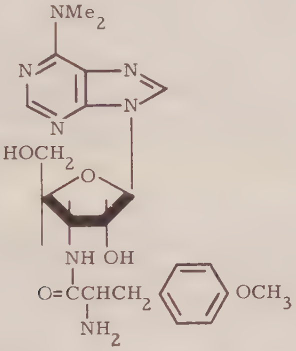
(6-Dimethylamino-9[3'-(p-methoxy-L-phenylalanylamino)-β-D-ribofuranosyl]-purine)
The trademark of Lederle Laboratories Division, American Cyanamid Company, for puromycin is Stylomycin.

SOURCE Streptomyces albo-niger [1] ; by synthesis [3] .

NATURE Diacidic base [2] .

MOLECULAR FORMULA $C_{22}H_{29}N_7O_5$; 471.52 (calc.).[2]

STRUCTURE



[2, 3]

CRYSTAL FORM AND COLOR White crystals [1] .

MELTING POINT (°C) Base: 175.5-177 (uncorr.) [1, 2] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -11°$[3] [2] .

/1/ From n-butanol. /2/ Originally named Achromycin; the Lederle Laboratories trademark "Achromycin" was transferred to the antibiotic with the generic name tetracycline. /3/ Ethanol.

UV ABSORPTION MAXIMA 275 mμ[1] [3] ; 267.5 mμ[2] [4] .

SOLUBILITY HCl: s. lower alcohols, water; sl. s. ethyl acetate, ethyl methyl ketone; i. petroleum ether, ether, chloroform. Base: s. aqueous alcohols; less s. anhydrous alcohols, most organic solvents; i. water, ether, petroleum ether.[4]

STABILITY Thermo- and pH stable [4] .

OTHER REACTIONS Readily forms a dihydrochloride or monosulfate; negative Brady. Infrared: 3309, 3200, 3125, 1645, 1600, 1560, 1512, 1428, 1403, 1345, 1303, 1248, 1230, 1184, 1158, 1107, 1070, 1040, 998, 968, 930, 871, 820, 791, 758 (recip. cm).[1, 2]

BIOLOGICAL ACTIVITY Active against certain bacteria and protozoa. In vitro. Inhibits (μg/ml) Bacillus cereus, B. subtilis, Klebsiella pneumoniae, Micrococcus pyogenes var. aureus, Sarcina lutea, 2-8; Mycobacterium sp, 40; Alcaligenes sp, 62; Salmonella pullorum, 150; S. typhosa, S. gallinarum, Escherichia coli, Proteus vulgaris, 200-400.[1] Protozoa: Inhibited Trypanosoma cruzi in dilution of 1:40,000 [5] ; T. gambiense, 1:15,000-1:30,000 [6] ; Tetrahymena pyriformis (strain W), 2 μg/ml [7] . In tissue cultures, exposure to concentrations of 2-40 μg/ml for 1/2-24 hours caused irreversible damage to several malignant tumor tissues [8]. Mouse mammary (Bittner) tumor and mouse brain tumor 8110 inhibited by 2.5-4.0 μg/ml [9] . Concentrations of 2 mg/ml partially inactivated virus of herpes simplex [23] .

In vivo. Daily i.p. doses of 80 mg/kg for 15 days suppressed Trypanosoma cruzi infection in rats [24] . I.p. doses of 10-20 mg/kg/ da in mice suppressed infections with T. cruzi and T. equiperdum; i.v. doses of 20 mg/kg for 7-14 days caused disappearance of well-developed lesions in rabbits.[5, 10, 11] Good protection in mouse infections with T. evansi, T. equinum; somewhat less against T. rhodesiense, T. gambiense; little or no activity against T. congolense.[11] Single large i.p. doses of 200-250 mg/kg failed to protect mice against T. gambiense and T. rhodesiense, but the same infections were controlled with 30-60 mg/kg daily for 10-12 days [25] . Protection afforded against T. equiperdum in mice by a number of puromycin analogs following single i.p. or oral doses of 25-50 mg/kg [12] . Oral doses of 6.2-50 mg/kg, b.i.d., for 5 days effective against Entamoeba histolytica infection in rats and guinea pigs; certain analogs were less active.[13, 14] Prolonged survival time in mice infected with Toxoplasma gondii following 0.05-0.4% of drug in the diet, or daily oral doses of 100-200 mg/kg [15, 16] . Single oral doses of 100-500 mg/kg were highly effective against mouse oxyurids (Aspiculuris tetraptera and Syphacia obvelata), and partially suppressed tapeworm (Hymenolepis nana var. fraterna) in mice [17] . Four daily i.p. doses of 90 mg/kg in mice effective against infection with Babesia rodhaini (Piroplasmidea), completely clearing the blood of the parasites [31] . Doses of 100 mg/kg/da, i.p., for 7 days failed to suppress RC carcinoma in mice [32]. Carcinolytic activity demonstrated in transplanted leukemia in mice [33] . Active against transplanted mouse mammary adenocarcinoma; slightly effective against mouse sarcoma 180 following i.p. or oral dosage; 100-200 μg partially suppressed development of glioblastoma in chick embryos. No activity against mouse and rat leukemia.[18] A number of amino acid analogs also were effective against mouse mammary adenocarcinoma. Carcinostatic activity closely paralleled trypanostatic property; no correlation with activity against bacteria and the protozoan, Tetrahymena pyriformis.[19]

CLINICAL Effectively controlled T. gambiense infection in 15 patients treated with daily oral doses of 1-2.25 g for 8-10 days, with excellent clinical response 24-48 hours after initiation of therapy [6, 29] . Slight to moderate tumor regression observed in 14 out of 50 patients with disseminated or advanced incurable neoplastic disease [8] . In a series of 24 cases of acute ulcerative amebiasis, there was effective clearance of E. histolytica after 10 daily oral doses of 1.5 g, but control of symptoms and healing of ulcers was slow as compared with results following therapy with tetracycline antibiotics [28] . Clinical response poor in patients with amebic liver abscess; good results obtained with puromycin in combination with tetracycline.[34] 60 patients with chronic amebiasis responded favorably to oral treatment of 12.5-25 mg/kg/da for 3 days; E. histolytica cleared from stools of 75-98% of patients, and stools were negative one year later. The 12.5 mg/kg doses were well tolerated; 25 mg/kg occasionally produced nausea, asthenia, headache, and diarrhea.[26] No significant response in 5 cases of Chagas' disease (T. cruzi) treated with total doses of 4-23 g over periods of 8-29 days [27] .

ACUTE TOXICITY LD_{50} in mice, 335-360 mg/kg, i.v.; 525-580 mg/kg, i.p.; 678-720 mg/kg, oral. LD_{50} in guinea pigs, 202 mg/kg, i.m.; 287 mg/kg, i.p., ; and 600 mg/kg, oral.[1, 20] Oral or i.v. doses of 50 mg/kg poorly tolerated in dogs; total amounts of 150-200 mg, in divided doses over 2-3 hour period, were well tolerated in anesthetized cats, with little or no effect on blood pressure, cardiac rate, and respiration.[20] Maximum tolerated dosage in mice was 150 mg/kg/da, i.p., for 4 days [31] .

CHRONIC TOXICITY Evidence of renal damage in animals following repeated parenteral administration of 25-100 mg/kg for 1-4 weeks [1] . Repeated oral doses of 100 mg/kg toxic to guinea pigs [13] . Daily i.p. doses of 25 mg/kg in rats over period of 10 days were well tolerated; doses of 100 mg/kg resulted in weight loss and histopathologic changes in the kidneys and bone marrow. Multiple i.m. doses of 10 mg/kg/da for 25 days well tolerated in dogs; 50 mg/kg doses were toxic. Repeated instillations of 0.5% buffered aqueous solutions were non-irritating to rabbit eye [20] .

In man, total oral doses of 9.5-21.0 g over periods of 8-10 days well tolerated; headache and gastrointestinal distress were occasional side effects.[6]

/1/ 0.1 N NaOH. /2/ 0.1 N HCl.

259. PUROMYCIN (Concluded)

ABSORPTION AND EXCRETION Appears to be readily absorbed from all tissues since effective doses by several routes are within same general range [5, 20] . Probably rapidly changed in the body and excreted by the kidneys in altered form [20, 21] . Only small amounts (5-7%) of the antibiotic appeared to be bound by plasma; the bound portion was almost entirely in the albumin fraction.[30]

MODE OF ACTION Trypanostatic rather than trypanocida [5] . Aminonucleoside is the active antitumor moiety in the puromycin molecule [22] . Trypanostatic activity of puromycin and its aminonucleoside reversed in vivo by adenine sulfate and various substituted purines; has been suggested that the antibiotic is an antimetabolite of adenine or its analogs.[21] Inhibition of strain W of Tetrahymena pyriformis reversed by guanylic acid, a metabolite of this organism, hence it has been postulated that the antibiotic interferes with synthesis of nucleic acids or nucleoproteins in these protozoa [7, 21] .

260. PYO COMPOUNDS

SOURCE Pseudomonas aeruginosa [1, 3] .

NATURE Pyo Ib: 2-heptyl-4-quinolinol.
Ic: 2-nonyl-4-quinolinol.
III: 2-(Δ'-nonenyl-)-4-quinolinol.[2]

MOLECULAR FORMULA AND WEIGHT Pyo Ib: $C_{16}H_{21}NO$; 440 (Rast)[1]; 243.3 (calc.).
Ic: $C_{18}H_{25}NO$; 486 (found); 271.4 (calc.).
II: $C_{17}H_{23}NO_2$; 546 (found); 273 (calc.).
III: $C_{18}H_{23}NO$; 502 (found); 269.4 (calc.).
IV: $C_{16}H_{23}NO_3$; 280, 285 (found); 277.4 (calc.).[1, 2]

CRYSTAL FORM AND COLOR Pyo Ib, III: colorless crystals.
II: light yellow platelets.
IV: colorless needles.[1]

MELTING POINT (°C) Pyo Ib: 146.2-147.
Ic: 138.8-139.2.
II: 149-149.5.
III: 151.5-153.5.
IV: 131-132; 139.5-140.[1, 2]

UV ABSORPTION MAXIMA (In mμ) [1, 2]

	In 95% ethanol	In 0.01 N ethanolic HCl	In 0.009 N ethanolic KOH
Pyo Ib	236, 316, 328	232, 300	242, 314
Ic	236, 316, 328	232, 300	244, 314
II	242, 330		
III	258, 266, 307, 338	258, 267, 320	260, 326
IV	232, 258, 340		

SOLUBILITY Pyo Ib, Ic, III: s. alcohols, chloroform, benzene, dioxane, acetone, ether.
II: s. aqueous carbonate; sl. s. cold acetone, benzene, methanol; i. petroleum ether, water, 5% sodium bicarbonate.[1, 2]

STABILITY Stable [1] .

OTHER REACTIONS Iodinated derivatives of Pyo Ib, Ic, II, and III have greater antibiotic activity than the parent compounds; both types inactivated by serum.
Pyo Ib and Ic: Precipitated from ether by oxalic, flavianic, hydrochloric acids, and occur in $NaHCO_3$ purification fractions.
II: Negative $FeCl_3$, Ag and Ba salts and reacts with diazomethane.
IV: Forms dibenzoate and 2, 4-dinitrophenylhydrazone.[1, 3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1, 3] .

BIOLOGICAL ACTIVITY In vitro. Pyo II: Inhibits (units/ml) M. pyogenes var. aureus, Corynebacterium diphtheriae, C. hoffmanni, Bacillus anthracis, B. subtilis, Diplococcus pneumoniae, Streptococcus pyogenes, 1-64. Less sensitive: Str. viridans, Brucella abortus, Br. suis, Br. melitensis, Salmonella typhosa, S. enteritidis, Serratia marcescens, Escherichia coli, Proteus vulgaris, 128-256 units/ml.[1]

/1/ Molecular weights found are approximately twice the calculated because they dimerize in the tribromophenol in which they are determined.

Ic: Inhibits M. pyogenes var. aureus, Str. pyogenes, E. coli, C. xerose in dilutions of 1:20-1:320 [1] .

In vivo. Pyo II: Inactive in experimental infections with D. pneumoniae in mice, or Mycobacterium tuberculosis in guinea pigs [4] .

TOXICITY Pyo II: LD_{100} in mice, approximately 38 mg/kg, i.p. [4] .

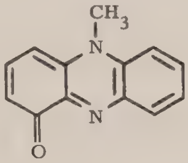
261. PYOCYANINE

SOURCE Pseudomonas aeruginosa [1, 2] .

NATURE Basic blue pigment [1] .

MOLECULAR FORMULA $C_{13}H_{10}ON_2$ [1] .

STRUCTURE



[1]

CRYSTAL FORM AND COLOR Dark blue needles [2] .

MELTING POINT (°C) 130 (d.) [2] .

SOLUBILITY s. hot water, dilute alcohol, chloroform, acetone, ethyl acetate, pyridine; i. ether, benzene, xylene, carbon tetrachloride, petroleum ether, carbon disulfide.[2]

STABILITY Unstable, but salts are stable [2] .

OTHER REACTIONS Acts as respiratory enzyme; picrate, MP 194-195°C (d.); perchlorate, MP 221-223°C (d.); salts dark red in color; turns green when treated with nitrous acid in cold; color destroyed by potassium permanganate, ferrous sulfate; unaffected by potassium ferrocyanide.[1, 2]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Bacillus anthracis, Neisseria catarrhalis and other bacteria in dilution of 1:10,000 or higher. Fungi: Achorion schoenleinii, Microsporum gypseum, Trichophyton mentagrophytes, Candida albicans inhibited by 1:2000-1:5000.[3]

TOXICITY LD_{100} in mice, approximately 100 mg/kg, i.p. [4] .

262. PYOLIPIC ACID

SOURCE Pseudomonas aeruginosa [1] .

NATURE Acidic lipoid [1] .

MOLECULAR FORMULA $C_{11}H_{22}O_3$ (proposed) [1] .

FORM AND COLOR Colorless, odorless, viscous oil [1] .

OPTICAL ACTIVITY $[\alpha]_D^{20} = -18.9^\circ$ [1] .

SOLUBILITY s. most fat solvents. Lead salt: s. alcohol, ether; i. water.[1]

OTHER REACTIONS Contains DL-β-hydroxydecanoic acid and a carbohydrate [1] .

QUANTITATIVE DETERMINATION Manometric: Oxygen uptake with Mycobacterium tuberculosis [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibited Myco. tuberculosis in dilution of 1:10,000-1:30,000 [2] .

263. PYRIDOMYCIN

SOURCE Streptomyces albidofuscus, n. sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{26-27}H_{32}O_8N_4$ (proposed); 531 (Rast).[3]

263. PYRIDOMYCIN

CRYSTAL FORM AND COLOR Colorless needles [1, 3] .

MELTING POINT (°C) 222 [1] ; 218-222 [2] ; 214-216.[3]

UV ABSORPTION MAXIMA 303-304 mμ[1]; 303 mμ[2]; 331 mμ[3].[1-3]

SOLUBILITY s. methanol, ethanol, butanol, ethyl acetate, butyl acetate, benzene, chloroform, acetone, dioxane, cellosolve, tetrahydrofuran; sl. s. ether, petroleum ether, water[4].[1, 3]

OTHER REACTIONS Negative $FeCl_3$, Fehling, fuchsin, Tollens, ninhydrin, Millon.

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis, Myco. phlei, Proteus vulgaris, 1.6; Escherichia coli, 3.2-25; Salmonella enteritidis, 6.3; S. schottmuelleri, S. typhosa, Shigella dysenteriae, 100->100; Bacillus anthracis, 100; B. subtilis, Candida albicans, >100.[1, 3]

In vivo. Daily i.p. doses of 5 mg slightly inhibited ascites production in Ehrlich carcinoma in mice, but did not prolong the survival time of these animals [4] .

TOXICITY LD_0 in mice, 830 mg/kg, i.p.; 1000 mg/kg, oral.[3]

264. QUADRIFIDINS

SOURCE Coprinus quadrifidus [1] .

NATURE Quadrifidin A_1: acidic.
A_2, B_2, B_3: neutral.[1]

CRYSTAL FORM AND COLOR Quadrifidin B_1: feathery colorless crystals which rapidly darken.
B_2: white crystals turning black.
B_3: strongly dichroic white crystals.[1]

UV ABSORPTION MAXIMA Quadrifidin B_2: 274 mμ[5].
B_3: 265, 276, 294, 313 mμ[5].[1]

SOLUBILITY Quadrifidin A_1, A_2, A_3: s. ether, chloroform, ethanol; sl. s. water, hexane.
B_1, B_2, B_3: s. ether, ethanol; sl. s. water, hexane.[1]

STABILITY Quadrifidin A_1: thermolabile at acid pH.
A_2, A_3, B_1, B_2, B_3: unstable.
B_3: particularly unstable to light.[1]

OTHER REACTIONS A_1, B_2, B_3: reduced ammoniacal $AgNO_3$; positive Schiff, 2, 4-dinitrophenylhydrazine.
B_2: highly unsaturated; inactivated by silver oxide, cysteine (latter reversible with I).
B_2, B_3: negative $FeCl_3$.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Quadrifidin B_2: Inhibits Mycobacterium tuberculosis in dilution of 1:144,000; M. pyogenes var. aureus, 1:576,000. Bacillus anthracis also sensitive.

B_1, B_2: Inhibit M. pyogenes var. aureus, Escherichia coli, Salmonella typhosa, S. enteritidis, Shigella paradysenteriae, Myco. phlei and B. subtilis.[1]

TOXICITY Quadrifidin B_2: Mice tolerated 25 mg/kg, i.v. [1] .

265. QUATRIMYCIN
(Epitetracycline)[6]

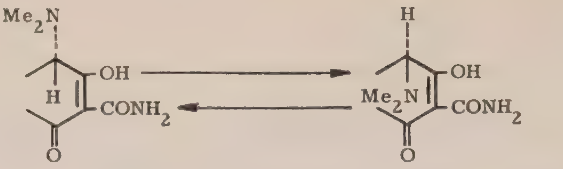
NATURE An isomer of tetracycline [1] .

MOLECULAR FORMULA $C_{22}H_{24}N_2O_8$ [2] .

/1/ Alcohol. /2/ 0.1 N HCl. /3/ 0.1 N NaOH. /4/ 50 μg/ml at room temperature. /5/ Ether. /6/ Corresponding synonyms for related compounds: for chlortetracycline, chlorquatrimycin; for oxytetracycline, oxyquatrimycin; for bromotetracycline, bromoquatrimycin.

265. QUATRIMYCIN (Concluded)

STRUCTURE



[2, 3]

MELTING POINT (°C) 170-171 (d.) [2] .

OPTICAL ACTIVITY $[\alpha]_D^{25} = -339^{\circ}$[1] [2] .

OTHER REACTIONS Isoelectric point greater than that of tetracycline; less in vitro activity than tetracycline; Escherichia coli activity is 2-5% that of tetracycline by turbidimetric assay.[1]

BIOLOGICAL ACTIVITY In vitro. Antibacterial activity of lower order than that of tetracycline [1] .
In vivo. Shows broad activity against experimental bacterial infections [1] .

266. RACTINOMYCINS

SOURCE Streptomyces of S. phaeochromogenus group [1] .

MOLECULAR FORMULA AND WEIGHT Ractinomycin A: $C_{32}H_{31}N_3O_{13}$ or $C_{64}H_{60}N_6O_{26}$ (proposed) [1] .

CRYSTAL FORM AND COLOR Ractinomycin A: yellow needles.
B: reddish-orange needles.[1]

MELTING POINT (°C) Ractinomycin A: 148-150 (d.).
B: 172-175 (d.). [1]

UV ABSORPTION MAXIMA Ractinomycin A: 245, 440-450 mμ[2].
B: 250, 400-450 mμ[2].[1]

SOLUBILITY Ractinomycin A: s. chloroform, acetone, ethyl acetate, butyl acetate; less s. methanol, ethanol, benzene, carbon disulfide; sl. s. ether, carbon tetrachloride; i. water, petroleum ether, 5% $NaHCO_3$.
B: Same as A but of lower order.[1]

STABILITY Ractinomycin A, B: thermolabile above pH 7; stable at room temperature at pH 2-10.[1]

OTHER REACTIONS Ractinomycin A: C, 57.80, 57.84; H, 4.55, 4.56; N, 6.25, 6.44; O, 31, 30 (calc.); negative ninhydrin, biuret, Millon; positive $FeCl_3$, Tollens; aqueous solution yellow at acid, violet at alkaline pH; in concentrated H_2SO_4 first reddish violet, later blue; in concentrated HCl, first orange than violet on heating; in 10% NaOH, first violet than reddish violet. R_f in 3% NH_4Cl, 0.21; in H_2O-saturated butanol, 0.95; in 15% acetone, 0.4.
B: Color reactions differ from A as follows: negative $FeCl_3$; orange yellow at acid, violet at alkaline pH in aqueous acetone; violet in concentrated H_2SO_4; insoluble in concentrated HCl and 10% NaOH; brown when suspended in 10% NaOH and heated. R_f in 3% NH_4Cl, 0.04; H_2O-saturated butanol, 0.95; 15% acetone, 0.1.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus flavus, Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Ractinomycin A: Inhibits (μg/ml) M. pyogenes var. aureus, 0.1-0.2; Sarcina lutea, B. anthracis, 0.2; M. flavus, B. megatherium, 0.4; B. subtilis, 0.4-0.8; Shigella dysenteriae, 50; Proteus vulgaris, 100; Mycobacterium tuberculosis, Myco. phlei, 12.5; Myco. butyricum, 6.3-12.5. Penicillium chrysogenum, Trichophyton mentagrophytes, Saccharomyces cerevisiae, Sac. saké, 25; Candida albicans, Aspergillus niger, 50. Not sensitive to 100 μg/ml: Escherichia coli, Salmonella paratyphi, S. schottmuelleri, Pseudomonas aeruginosa.
B: Inhibits (μg/ml) M. pyogenes var. aureus, 0.1; B. anthracis, 0.2; M. flavus, Sarcina lutea, 0.8; B. subtilis, 0.8-1.6; E. coli, Salmonella paratyphi, Sh. dysenteriae, Pr. vulgaris, 50; S. schottmuelleri, Ps. aeruginosa, 100; Myco. phlei, Myco. butyricum, 3.1; Myco. tuberculosis, 6.3. C. albicans, Sac. cerevisiae, 0.4-0.8; P. chrysogenum, T. mentagrophytes, 0.8; Sac. saké, 0.8-1.6; A. niger, 6.3.[1]
In vivo. Ractinomycin A: Daily i.p. doses of 6 μg in mice showed no antitumor activity against Ehrlich carcinoma [1] .

TOXICITY Ractinomycin A: LD_{50} in mice, approximately 10 mg/kg, i.p.
B: Mice tolerated 25 mg/kg, i.p.[1]

/1/ 0.5% in methanol, 0.1N HCl. /2/ Methanol.

267. RAISNOMYCIN

SOURCE Streptomyces kentuckensis, n. sp [1] .

NATURE Basic [1] .

COLOR Dark yellow [1] .

SOLUBILITY s. ethanol, methanol, butanol, isopropanol; i. water, acetone, ether. HCl and -SO_4: sl. s. water.[1]

BIOLOGICAL ACTIVITY *In vitro.* Inhibited by 100 µg/ml or less: Micrococcus pyogenes var. aureus (including tetracycline-resistant strains), Diplococcus pneumoniae, Streptococcus pyogenes, Str. faecalis, Str. viridans, Bacillus subtilis, B. anthracis, Salmonella typhosa, S. pullorum, S. schottmuelleri, Shigella dysenteriae, Sh. paradysenteriae, Escherichia coli, Aerobacter aerogenes, Proteus vulgaris, Brucella abortus, Pasteurella multocida. Resistant to 100 µg/ml: Klebsiella pneumoniae, Pseudomonas aeruginosa, Br. bronchiseptica, Mycobacterium tuberculosis var. hominis; also Candida albicans and Torula histolytica.[1]

TOXICITY LD_{50} of crude preparations in rats, 28-35 mg/kg (route not given) [1] .

MODE OF ACTION Action is bactericidal as well as bacteriostatic [1] .

268. RAMNACIN

SOURCE Streptomyces sp [1] .

MOLECULAR FORMULA AND WEIGHT $C_{26}H_{43}O_8$ (proposed); 499 (Rast).[1]

MELTING POINT (°C) 235 [1] .

SOLUBILITY s. alcohol, acetic acid, ethyl acetate, chloroform, ether; less s. benzene, petroleum ether (80-100°C); sl. s. water [1] .

STABILITY Very stable [1] .

OTHER REACTIONS Does not decolorize Br in CCl_4; positive test for benzenoid structure; paper chromatography on n-butanol/acetic acid/water (4:1:5) gives 1 substance with an R_f value of 0.92; C, 64.51; H, 8.97.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis NCIB 3610 [1] .

BIOLOGICAL ACTIVITY *In vitro.* Activity shown against B. cereus var. mycoides, B. subtilis, Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Sarcina lutea, Proteus vulgaris. Pseudomonas aeruginosa not sensitive. Also active against Helminthosporium sp and Penicillium sp. No activity against P. notatum, P. chrysogenum, Aspergillus sp, and various yeasts.[1]

269. RESISTOMYCIN

SOURCE Streptomyces resistomycificus, n. sp [1] .

NATURE Weakly acidic [1] .

MOLECULAR FORMULA AND WEIGHT $C_{23}H_{18}O_6$ [1] ; 386 ± 5 (found); 390.4 (calc.).[2]

CRYSTAL FORM AND COLOR Yellow needles [1, 2] .

MELTING POINT (°C) 315 (d.) [1, 2] .

SOLUBILITY s. ether, benzene, ethanol, acetone, glacial acetic acid; sl. s. water. [1]

STABILITY Very thermostable; acid and alkali stable [1, 2] .

OTHER REACTIONS Orange-red in NaOH, piperidine, and on heating over 300°C; red in pyridine; fluorescence in ethanol, benzene, acetone, H_2SO_4; yellow precipitate with original activity after heating with H_2SO_4; present in mycelium and too insoluble to detect by agar diffusion tests.[1, 2]

BIOLOGICAL ACTIVITY *In vitro.* Inhibits Micrococcus pyogenes var. aureus, Bacillus subtilis in dilution of 1:20,000,000; Mycobacterium tuberculosis, 1:500,000-1:1,000,000.[1]

270. RHODOCIDIN

SOURCE Streptomyces phoenix, n. sp [1] .

270. RHODOCIDIN (Concluded)

SOLUBILITY s. water, organic solvents [1] .

STABILITY Rapidly inactivated when aeration of fermentation liquors was discontinued[1] ; stable in absence of mycelium; inactivated by dilute acid or alkali; stable indefinitely in organic solvents below 5°C; stable in lyophilized form unless moisture present.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis ATCC 6633 [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (units/ml)[2] B. subtilis, 0.02; Micrococcus pyogenes var. aureus, 0.03; Streptococcus sp, 0.25; Mycobacterium tuberculosis, 0.45; Klebsiella spp, 0.06; Proteus vulgaris, 0.11; Brucella abortus, 1.2; Salmonella typhosa, 4.5; Pseudomonas aeruginosa, Escherichia coli, 9.0.[1]

In vivo. I.p. doses gave protection in mice infected with Streptococcus sp [1] .

TOXICITY Highly toxic to mice. LD_{50}, 14,000 units/kg, i.v.; 15,000 units/kg, i.p.; 21,000 units/kg, i.m.[1]

271. RHODOMYCETIN
Name changed from rhodomycin.

SOURCE A mutant of Streptomyces griseus [1] .

NATURE Red pigment [1] .

FORM AND COLOR Dark red powder [1] .

MELTING POINT (°C) >300 [1] .

ABSORPTION MAXIMA 235, 540, 580 mμ; 520 mμ[3].[1]

SOLUBILITY Red form: s. ethylene glycol, monomethyl ether, ethyl ether, acetone, acetic acid, lower alcohols; i. water. Blue form: s. water.[1]

STABILITY Thermolabile, especially in alkali; blue form very unstable in water.[1]

OTHER REACTIONS Resembles actinorhodin. Red in acid, blue in alkaline solution; reddish-violet in concentrated H_2SO_4; amber with $FeCl_3$ added to alcoholic solution; decolorized by sodium hydrosulfite, not so by sodium bisulfite; decolorized by Zn dust in alcoholic solution when boiled with acid or alkali.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus, Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria; slight activity against mycobacteria; Gram-negative bacteria not sensitive.[1]

In vivo. No activity in mice infected with M. pyogenes var. aureus [1] .

TOXICITY Mice tolerated 200 mg/kg, s.c.; 25 mg/kg, i.p.[1]

272. RHODOMYCINS

SOURCE Streptomyces purpurascens, n. sp [1] .

NATURE Amphoteric pigment [1, 3] .

MOLECULAR FORMULA AND WEIGHT Rhodomycin A HCl: $C_{20}H_{29}O_7N\cdot HCl$ [3] , or $C_{19}H_{29}O_7N\cdot HCl$ [5] ; 431.9 (calc.) [3] ; 419.9 (calc.) [5] .

B HCl: $C_{19}H_{27}O_7N\cdot HCl$; 417.9 (calc.).[5]

CRYSTAL FORM AND COLOR Rhodomycin A HCl: long, fine dark-red needles [3] .

A, B HCl: red prisms [5] .

A perchlorate: fine red needles [5] .

MELTING POINT (°C) Rhodomycin perchlorate: 198 (d.) [1] .

A HCl: 193 (d.) [3] ; 205 [5] .

A perchlorate: 188 [5] .

B HCl: 180 [5] .

OPTICAL ACTIVITY Rhodomycin A HCl: $[\alpha]^{18}_{606-760}$ = +178° ± 10 [4] [5] .

B HCl: $[\alpha]^{18}_{606-760}$ = +174° ± 10 [5] [5] .

/1/ 0.03% H_2O_2 added to beer before filtration. /2/ 400-7000 units/mg. /3/ Concentrated H_2SO_4. /4/ c, 0.13 methanol. /5/ c, 0.05 methanol.

272. RHODOMYCINS (Concluded)

ABSORPTION MAXIMA Rhodomycin A HCl: 566, 532, 498 $m\mu^{1}$; 600, 542, 501 $m\mu^{2}$; 535, 500 $m\mu^{3}$; 587, 545, 507 $m\mu^{4}$.[3] 532, 494 $m\mu^{1}$ [5].
B HCl: 530, 496 $m\mu^{1}$[5].

SOLUBILITY s. water, methanol, pyridine, acetic acid; sl. s. ether, chloroform, ethyl acetate, benzene, tetrahydrofuran.[3, 5]

STABILITY Thermo-, acid, and alkali labile [1, 2].

OTHER REACTIONS Red in acid, blue in alkaline solution; isoelectric point, 8.6; precipitated from aqueous solution by picric, picrolonic, styphnic, alizarinsulfonic, phosphotungstic, molybdic, chloroplatinic, chloroauric acids, and by $HgCl_2$, helianthin, $SnCl_2$, I_2-KI. Hydrolysis with dilute acid yields the N-free chromophores, rhodomycinone and isorhodomycinone, plus rhodosamine, $C_8H_{17}O_3N$, identified as 2, 6-desoxydimethylaminoaldohexose. Rhodomycins A and B and isorhodomycins A and B can be separated by ring chromatograms.[1, 3-5]

QUANTITATIVE DETERMINATION Microbiological: Microccus pyogenes var. aureus [1-3].

BIOLOGICAL ACTIVITY In vitro. Inhibit M. pyogenes var. aureus in dilution of 1:50,000,000 [2].
Rhodomycin A: Inhibits M. pyogenes var. aureus in dilution of 1:30,000,000.
B: Inhibits the same microorganism in dilution of 1:5,000,000.[5]

273. RIMOCIDIN

SOURCE Streptomyces rimosus [1].

NATURE Amphoteric [1].

CRYSTAL FORM Sulfate: large, fragile plates [1].

MELTING POINT (°C) Sulfate: 151 (d.) [1].

OPTICAL ACTIVITY Sulfate: $[\alpha]_D^{25} = +75.2^{\circ\, 5}$[1].

UV ABSORPTION MAXIMA 279, 291, 304, 318 $m\mu^{1}$ [1].

OTHER REACTIONS Analysis: C, 57.65; H, 7.82; N, 1.81; S, 2.03.[1]

BIOLOGICAL ACTIVITY Active against fungi and certain protozoa. In vitro. Inhibits (μg/ml) Candida albicans, Blastomyces brasiliensis, Histoplasma capsulatum, Sporotrichum schenckii, Hormodendrum compactum, Phialophora verrucosa, Trichophyton violaceum, 5; Bl. dermatitidis, T. sulfureum, Cryptococcus neoformans, 10.[1] Protozoa: Entamoeba histolytica, 62.5-250; Leishmania donovani, L. tropica, Trypanosoma cruzi, 12.5; Trichomonas vaginalis, 25.[2, 3]

In vivo. No activity in mice infected with Trypanosoma cruzi [4], or Candida albicans [5]; no protection against Plasmodium cathemerium in canaries [6].

TOXICITY LD_{50} in mice, 20 mg/kg, i.v. In vitro. Hemolysis of rabbit red blood cells in concentration of 30 μg/ml.[1] Low levels (0.012 μg/ml) toxic to human spermatozoa [7].

ANIMAL NUTRITION Stimulated growth of chicks when fed at levels of 10-25 mg/kg [8], but had little or no effect on the growth of pigs [9].

MISCELLANEOUS Concentrations of 25-100 ppm controlled Ascochyta pisi infection of pea seeds. Concentrations of 200 ppm were non-toxic to the seeds.[10] Growth of wheat roots in distilled water was slightly stimulated by addition of 1 ppm of antibiotic [11]. Concentrations of 10 μg/ml in tissue culture media for cultivation of poliomyelitis virus have been useful for controlling fungal contaminations [12]. Showed molluscacidal activity; concentrations of 3.9 μg/ml were lethal to snails (Australorbis glabrata) in 24 hours [13].

274. ROSEIN II

SOURCE Trichothecium roseum [1].

NATURE $C_{19}H_{28}O_3$; 278, 337 (Rast); 304 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless fibrous needles [1].

MELTING POINT (°C) 186 [1].

/1/ Methanol. /2/ Pyridine. /3/ Acetic anhydride. /4/ Acetic anhydride and pyroboracetate. /5/ c, 1 methanol.

274. ROSEIN II (Concluded)

OPTICAL ACTIVITY $[\alpha]_D^{23} = +5.9^{\circ 1}$; $[\alpha]_{5461}^{20} = +7.5^{\circ 2}$.[1]

SOLUBILITY s. most organic solvents, hot alkali; sl. s. petroleum ether; i. water, cold alkali.[1]

OTHER REACTIONS Associated with trichothecin and inactive roseins I and III; negative $FeCl_3$, Salkowski, Liebermann-Burchard; deep orange-yellow in concentrated H_2SO_4; potassium permanganate oxidation gives a monobasic acid $C_{16}H_{26}O_5$.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (µg/ml) Bacillus subtilis, 4; Mycobacterium phlei, 12. Slightly active against Myco. tuberculosis. Rosein I and III are devoid of antibacterial activity.[1]

275. ROSEOMYCIN

SOURCE Streptomyces roseochromogenus [1] .

NATURE Basic [1] .

REACTIONS Streptothricin-like; from pure HCl, crystalline helianthate (211-216°C, d.) and crystalline reineckate (114°C, d.) were obtained; positive Fehling, glucosamine, Molisch, Tollens, indole; negative biuret, ninhydrin, xanthoproteic, Adamkiewicz, Liebermann, Neubauer, Sakaguchi, maltol.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Vibrio comma, Escherichia coli, Pasteurella tularensis, Mycobacterium spp, Salmonella typhosa [1, 2, 4] .

In vivo. Good protection in mice infected with V. comma and S. typhosa [2, 3] . Excellent protection against Past. tularensis with doses of 1 mg/da [4] .

TOXICITY Mice tolerated 1000 mg/kg, i.v. or i.m. [1] .

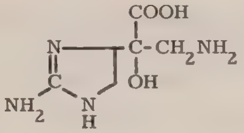
ANIMAL NUTRITION In diet, 15-45 µg/kg ration promoted growth in chicks[5] .

276. ROSEOTHRICIN

SOURCE Streptomyces roseochromogenus [2] .

REACTIONS Streptothricin-like. Hydrolysis gave 2 products; β-ϵ-diaminohexanoic acid (also found in streptothricin, viomycin, streptolin), and a new amino acid, roseonine.

Roseonine:



[1]

BIOLOGICAL ACTIVITY In vitro. Low concentrations inhibit varied Gram-negative and Gram-positive bacteria. Spectrum resembles that of streptothricin.[2]

TOXICITY Fairly toxic to mice [2] .

277. ROTAVENTIN

SOURCE Streptomyces reticuli [2] .

CRYSTAL FORM AND COLOR White thin leaves turning yellow at 130°C [1] .

MELTING POINT (°C) 170-175 (d.) [1] .

SOLUBILITY s. methanol, ethanol, butanol, amyl alcohol, acetone; i. ether, petroleum ether, chloroform, benzene, ethyl acetate, amyl acetate, trichloroethylene, water, 5% aqueous $NaHCO_3$, acid water at pH 2.[1]

OTHER REACTIONS No N or S; not precipitated in methanol or ethanol by adding phosphotungstic acid, flavianic acid, methyl orange, picric acid, lead acetate, or Ca, Hg, or Ba chlorides; red color with concentrated H_2SO_4.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Aspergillus flavus, A. niger, A. oryzae, Penicillium glaucum, P. chrysogenum, Torula rubra, Saccharomyces saké, 6 µg/ml. Little or no activity against Mucor mucedo, Rhizopus nigricans, Trichophyton interdigitale, Botrytis bassiana, Candida albicans, and bacteria.[2] Inhibits Trichomonas vaginalis in concentration of 100 µg/ml [3] .

/1/ c, 2 chloroform. /2/ c, 1 ethanol.

277. ROTAVENTIN (Concluded)

TOXICITY Mice tolerated 150 mg/kg, i.p.; 770 mg/kg, s.c.[2]

278. RUBIDIN

SOURCE Streptomyces sp [1] .

NATURE Quinonoid pigment [1] .

FORM AND COLOR Red powder [1] .

ABSORPTION MAXIMA 500, 530 mμ[1]; 400, 520 mμ[2]; 320, 415 mμ[3]; 530 mμ[4].[1]

SOLUBILITY s. most organic solvents; sl. s. sodium bicarbonate; i. petroleum ether.[1]

STABILITY Stable at acid, unstable at alkaline pH [1] .

OTHER REACTIONS Blue at alkaline, red at acid pH; positive $FeCl_3$ in ethanolic solution; decolorized at room temperature by Zn dust in presence of HCl or NaOH, the pigment reappearing on aeration; similarly decolorized with sodium bisulfite. Analysis: C, 51.9; H, 5.56; O, 42.54.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Crude preparations inhibited (μg/ml) M. pyogenes var. aureus (including strain resistant to streptomycin and penicillin) at 1.5-2.5; Bacillus subtilis, Vibrio comma, 2.5; Streptococcus faecalis, 5; Mycobacterium phlei, 15; Proteus vulgaris, 20; Shigella dysenteriae, Salmonella typhosa, Pseudomonas aeruginosa, 100. Resistant, >200 μg/ml: Escherichia coli, Klebsiella pneumoniae, Agrobacterium tumefaciens; also Aspergillus niger.[1]

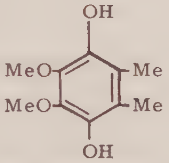
279. RUBROGLIOCLADIN

SOURCE Gliocladium roseum [1] .

NATURE Quinhydrone [1, 2] .

MOLECULAR FORMULA $C_{20}H_{26}O_8$ [1] .

STRUCTURE Quinhydrone formed from



[2]

CRYSTAL FORM AND COLOR Dark red needles [1] .

MELTING POINT (°C) 74 [1] .

UV ABSORPTION MAXIMA 275, 407 mμ [1] .

SOLUBILITY s. organic solvents, water [1] .

OTHER REACTIONS Monodinitrophenylhydrazone produced when treated with 2,4-dinitrophenylhydrazine [1] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis, Botrytis allii spores [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) B. allii in concentrations of 50; also inhibits Bacillus subtilis, 200, Escherichia coli, 400.[1]

280. RUBROMYCIN

SOURCE Streptomyces collinus, n. sp [1] .

CRYSTAL FORM AND COLOR "Beam-like" thin crystals; pale violet microscopically, red macroscopically.[1]

MELTING POINT (°C) 215 (d.) [1] .

/1/ 0.1N HCl. /2/ 0.1N NaOH. /3/ n-Butanol. /4/ Concentrated H_2SO_4.

280. RUBROMYCIN (Concluded)

ABSORPTION MAXIMA 584, 546 mμ[1]; 518-520 mμ[2].[1]

SOLUBILITY s. acetone, chloroform; less s. ether, lower alcohols; i. water, petroleum ether, sodium bicarbonate solution.[1]

OTHER REACTIONS Red methylene chloride solution + aqueous $NaHCO_3$ gives red-violet precipitate of Na salt at interface; red color is lost on shaking in aqueous dioxane with sodium hyposulfite (but not with sodium bisulfite), becoming red again on standing in air; blue-green solution in pyridine-methanol with titanium trichloride, becoming red-violet after a short time. Analysis: C, 60.3; H, 4.26; O, 33.91. Acetate crystallizes as yellow needles, MP 193-195°C (uncorr.); resembles rhodomycetin, but differs in being only found in mycelium.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Streptococcus spp, Corynebacterium diphtheriae, Bacillus subtilis in dilution of 1:800,000; Micrococcus pyogenes var. aureus, Streptococcus group D, 1:100,000; Escherichia coli, Salmonella typhosa, 1:10,000.[1]

281. RUGULOSIN

SOURCE Penicillium rugulosum and P. wortmanni [1] .

NATURE Related to polyhydroxyanthroquinones [1] .

MOLECULAR FORMULA AND WEIGHT $C_{30}H_{22}O_{10}$; 413, 420 (cryo. in dioxane); 542 (calc.).[1]

CRYSTAL FORM AND COLOR Yellow cubes or prisms[3] [1] .

MELTING POINT (°C) 293 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]_{5461}^{18} = +605^{\circ 4}$ [1] .

SOLUBILITY s. acetone, dioxane, pyridine, ethyl acetate, glacial acetic acid; less s. methanol, ethanol, ether, chloroform, butanol, benzene, 2 N NaOH, 2 N Na_2CO_3, saturated $NaHCO_3$, NH_4OH; i. water, petroleum ether, concentrated HCl.[1]

OTHER REACTIONS Crystalline forms are very hygroscopic; antibiotic does not sublime on heating in high vacuum; solutions in chloroform and glacial acetic acid bright yellow with slightly green fluorescence; dissolves in concentrated H_2SO_4 giving pure yellow solution with slight fluorescence which changes on heating through brown to a stable purplish crimson color; olive brown color in ethanolic solution with $FeCl_3$; negative Brady, Schiff; no decolorization of Br in CCl_4 or acid $KMnO_4$; does not form a semicarbazone, methyl ester, or p-bromophenacyl ester.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (in dilution x 10^3) Micrococcus citreus, M. albus, Mycobacterium phlei, Myco. smegmatis, Escherichia coli, Salmonella typhosa, S. typhimurium, S. schottmuelleri, S. enteritidis, Shigella dysenteriae, Pseudomonas aeruginosa, Ps. fluorescens-2, M. pyogenes var. aureus-2-1024, Vibrio comma-16, Bacillus subtilis-256, Corynebacterium diphtheriae-512-4096, B. anthracis-1024-2048, B. cereus, Streptococcus viridans-2048, Str. pyogenes-2048-4096. Fungi: Inhibits Pythium intermedium in dilution of 1:50,000.[1]

In vivo. I.p. doses of 25 mg/kg protected mice against Str. pyogenes; no protection against Escherichia coli.[1]

282. RUTICIN

SOURCE Streptomyces sp, resembling S. rutgersensis [1] .

NATURE Acidic [1] .

CRYSTAL FORM AND COLOR Impure crystals: needles and rosettes. Pure crystals: orange needles.[1]

UV ABSORPTION MAXIMA 364, 262 mμ [1] .

SOLUBILITY Acid form: s. methanol, ethanol, ethyl acetate; sl. s. water. Sodium salt: s. water, methanol, ethanol; i. ethyl acetate, less polar solvents.[1]

STABILITY Rapid and irreversible inactivation in culture fluids when aeration is discontinued; addition of H_2O_2 stabilizes filtrates; crystalline antibiotic unstable after a few months at -20°C.[1]

OTHER REACTIONS Second antibiotic produced in complex media [1] .

/1/ In 2 N NaOH. /2/ In concentrated H_2SO_4. /3/ From ethanol or acetone. /4/ Dioxane; falls to +222° after exposure to light for periods of 14 days or more.

282. RUTICIN (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus pyogenes var. aureus, 0.08; Bacillus subtilis, 0.16; Proteus vulgaris, 0.64; Salmonella typhosa, 5.3.[1]

In vivo. Slight protection in mice infected with Streptococcus pyogenes after i.p. treatment; no protection when administered i.v. Appears to be inactivated in vivo.[1]

TOXICITY LD_{50} in mice, approximately 20 mg/kg, i.v. [1] .

283. SARCIDIN

SOURCE Streptomyces achromogenes, n. sp [1] .

MELTING POINT (°C) 274-275 (d.) [1] .

STABILITY Stable at 60°C for 1 hour at pH 2; 25% loss at pH 4, 75% loss at pH 7, 80% loss at pH 9.[1]

OTHER REACTIONS Analysis: C, 41.89; H, 5.02; N, 21.82; halogen, S.[1]

QUANTITATIVE DETERMINATION Microbiological: Sarcina lutea [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits S. lutea at 1.0-1.5 μg/ml. Other bacteria or fungi not sensitive.[1]

TOXICITY Mice tolerated 660 mg/kg, i.p. [1] .

284. SARKOMYCIN

SOURCE Streptomyces sp related to S. erythrochromogenes [2] .

NATURE Obtained only as an oil [6] .

UV ABSORPTION MAXIMUM 230 mμ[1] [6] .

SOLUBILITY Free acid: s. water, methanol, ethanol, butanol, ethyl acetate; sl. s. petroleum ether. Na salt: s. water, methanol, aqueous ethanol. Ca salt: s. water; sl. s. ethanol.[1]

OTHER REACTIONS Negative biuret, xanthoproteic, Sakaguchi, Molisch, Benedict, Fehling, Tollens, Seliwanoff, Foulger, picric acid; doubtful ninhydrin; positive nitroprusside, iodine azide; S present.[1, 2] All samples with antibacterial activity yield reddish pink anthrone test; non-crystalline precipitates obtained with 2,4-dinitrophenylhydrazine, with loss of activity. Infrared bands at 3.4, 5.8, 6.1, 6.9, 7.1, 8, 9.1, 10.5 μ. Hydrogenation destroys antibacterial activity and reaction to anthrone, the hydrogenated product being 2-methyl-3-oxocyclopentane carboxylic acid which does have antitumor activity.[6]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209-P[2] [1-3, 6] . A strain of hemolytic streptococcus. Anthrone test.[5]

BIOLOGICAL ACTIVITY Antitumor activity; some activity against bacteria and certain fungi. In vitro. Inhibits (μg/ml) Bacillus anthracis, M. pyogenes var. aureus, 25-50; Salmonella paratyphi, Shigella dysenteriae, 100; B. subtilis, Escherichia coli, Salmonella typhosa, S. schottmuelleri, Proteus vulgaris, 500-1000; Pseudomonas aeruginosa, Mycobacterium spp, >1000 μg. Nocardia asteroides inhibited by 63 μg/ml. Fungi (μg/ml) Histoplasma capsulatum, 63; Trichophyton mentagrophytes, 500; Torula utilis, Cryptococcus neoformans, Saccharomyces saké, 1000; Aspergillus niger, Penicillium chrysogenum, >1000. [2, 3] Concentrations of 750 μg/ml inhibited transplantability of Ehrlich ascites carcinoma [7] . Desquamation of HeLa (neoplasm) cells induced with concentrations of 30-60 μg/ml; these cells could not be subcultivated. Sulfhydryl compounds did not reverse this activity against HeLa cells.[8]

In vivo. Doses of 50-100 mg/kg, s.c. or i.p., prolonged survival time in rats with Yoshida sarcoma and in mice with Ehrlich carcinoma [2] . In another report activity was demonstrated against Usubuchi sarcoma in rats by prolongation of survival time; no effect on Yoshida and Hirosaki sarcomas.[8] In mice, daily doses of 1 mg, i.v., 2.5 mg, i.p., or 5 mg, orally, retarded development of Ehrlich carcinoma [1] . Little or no activity against Ehrlich carcinoma in mice when treatment was delayed until 2 days after transplantation [7] . Inhibited ascites production and prolonged survival time in mice with transplanted mouse sarcoma 180 [8] ; daily i.p. doses of 150-250 mg/kg in mice or rats had a marked inhibitory effect on ascites tumors, but little or no effect on solid tumors except carcinoma 1025 and Harding-Passey melanoma [11, 12] .

CLINICAL Clinical improvement in 26 of 78 cases of inoperable carcinoma following total i.v. doses of 5 and up to 114 g over periods of 8-46 days. No serious side effects observed.[4] Subjective and objective improvement observed in 7 of 11 cases of malignant tumor in children treated with i.v. doses of 100 mg up to 4 g per day [9] . Clinical trials in the United States have indicated no carcinostatic effect on various types of cancers [13, 16] .

/1/ Water; purest samples only, less pure giving only end absorption. /2/ Parallels antitumor activity.

PHARMACOLOGY Following i.v. administration in humans, approximately 18% of total dose recovered in urine with continuous excretion 3-11 hours after injection [5]. High concentrations (>1:200 or >100 mg/kg) inhibited cardiac action of isolated frog or rabbit heart, dilated rabbit auricular vessels, and had some diuretic action in dogs [10].

TOXICITY LD_{50} in mice, 1000-1800 mg/kg, i.p. [7]; 800-1600 mg/kg, i.v.; 400-800 mg/kg, s.c.; 4800-6400 mg/kg, oral.[1] Daily intravenous doses of 100 mg/kg were well tolerated in children; side effects were rare.[9]

MODE OF ACTION Cytologic studies with rat sarcoma cells (Hirosaki and Usubuchi types) supply evidence that the antibiotic acts neither as a mitotic poison nor as an antimetabolite, but specifically destroys tumor cells both in the dividing and resting stages [14].

MISCELLANEOUS Antitumor activity depressed by sulfhydryl compounds [2]; BAL, cysteine and serum decreased bacteriostatic activity and mouse toxicity [3]. One report describes the development of a fibrosarcoma in a rat which had received multiple subcutaneous doses of 0.05 mg of sarkomycin over a 5-month period; this tumor developed at the site of injection at the end of one year.[15]

285. SELIGOCIDIN
(Enteromycin)

SOURCE Streptomyces sp, resembling S. roseochromogenus [1].

UV ABSORPTION MAXIMUM 304 mμ [1].

SOLUBILITY s. methanol; sl. s. water, ethanol.[1]

OTHER REACTIONS Positive Sakaguchi, ninhydrin; negative biuret.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Candida albicans, C. tropicalis, Torula utilis, Botrytis bassiana, Streptomyces griseus, 3-6; Sporotrichum beurmanni, 0.7; Aspergillus niger, Cryptococcus neoformans, Penicillium chrysogenum, 12-25; Trichophyton rubrum, 50; Trichophyton mentagrophytes, 12-200. Actinomycetes and bacteria (μg/ml): Nocardia asteroides, 6; Bacillus anthracis, B. subtilis, B. agri, 50. Mycobacterium spp and Gram-negative bacteria not sensitive to 200 μg/ml.[1]

TOXICITY LD_{50} in mice, 200 mg/kg, i.p. [1].

286. SIMPLEXIN

SOURCE Bacillus simplex [1].

SOLUBILITY s. methanol, 95% alcohol; i. chloroform, ether, benzene, ethyl acetate, n-butanol.[2]

STABILITY Acid stable, alkali labile [2].

QUANTITATIVE DETERMINATION Microbiological: Rhizoctonia solani [1].

BIOLOGICAL ACTIVITY In vitro. Inhibits (units/ml) Pasteurella sp, Diplococcus pneumoniae, 0.13; Salmonella typhosa, Escherichia coli, 1.0; Micrococcus pyogenes var. aureus, S. paratyphi, >32.[3] Also inhibits R. solani [1].

In vivo. No protection in mice infected with D. pneumoniae and M. pyogenes var. aureus [3].

TOXICITY LD_0 in mice, approximately 1000 mg/kg [3].

287. SISTOMYCOSIN

SOURCE Streptomyces viridosporus, n. sp [1].

NATURE Neutral [1].

CRYSTAL FORM AND COLOR Buff or light yellow microcrystalline solid [1].

MELTING POINT (°C) Approximately 230[1] [1].

UV ABSORPTION MAXIMA 218, 300 mμ[2] [1].

SOLUBILITY s. water, methanol; less s. moist acetone, aqueous alcohols; i. chloroform, ether, ethyl acetate, benzene, petroleum ether.[1]

/1/ Turns brown at 130°C. /2/ Latter has 3 peaks: 292.5, 306, 320.5 mμ in water, weak acid or base.

287. SISTOMYCOSIN (Concluded)

STABILITY Unstable to light, acid, alkali; stable in water below 25°C; less than 50% loss in water at 100°C for 1 hour.[1]

OTHER REACTIONS Reduces cold aqueous $KMnO_4$ and boiling Benedict's solution; positive Molisch; negative Beilstein, $FeCl_3$; deep cherry-red to chocolate color when small amount is added to warm concentrated H_2SO_4; no color change when added to warm concentrated HNO_3 or HCl.[1]

QUANTITATIVE DETERMINATION Microbiological: Candida albicans [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (in concentration of 25 μg/ml or less) Blastomyces dermatitidis, Histoplasma capsulatum, Microsporum canis, Sporotrichum schenckii, Trichophyton rubrum, C. albicans. Little or no activity against Cryptococcus neoformans. Bacteria not sensitive.[1]

TOXICITY LD_{50} in mice, 90 mg/kg, i.v.; LD_0, 80 mg/kg, i.v.[1]

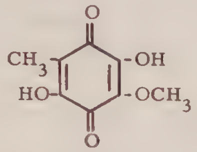
288. SPINULOSIN

(3, 6-Dihydroxy-4-methoxy-2, 5-toluquinone)

SOURCE Penicillium spinulosum [1] ; Aspergillus fumigatus [4] ; by synthesis [3] .

MOLECULAR FORMULA AND WEIGHT $C_8H_8O_5$ [1-3, 6] ; 184 (Rast); 184 (calc.) [1, 3, 4] .

STRUCTURE



[1-3]

CRYSTAL FORM AND COLOR Purplish-bronze or black plates [1, 3, 4, 6] .

MELTING POINT (°C) 201-203.5 [1, 3, 6] .

OPTICAL ACTIVITY Inactive [1, 3, 4, 6] .

SOLUBILITY s. hot water, ether; sl. s. cold water.[1]

STABILITY Thermostable at pH 2.0-9.5 [1] .

OTHER REACTIONS Polarographic properties; characteristic quinone odor; intense blue with concentrated H_2SO_4; blue-purple with N NaOH; intense brown in alcohol with $FeCl_3$; reduced by Zn and HCl to a colorless compound which gives a blue-green color with $FeCl_3$; buff to purple to colorless with increasing pH.[3]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [5] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Photobacterium fischeri, 16; M. pyogenes var. aureus, 63-170; Bacillus mycoides, B. subtilis, 125; B. anthracis, Salmonella typhimurium, Vibrio comma, 170; Escherichia coli, 100-250; Klebsiella pneumoniae, Mycobacterium phlei, 250; Myco. smegmatis, Pseudomonas aeruginosa, 500.[7, 8]

289. SPIRAMYCIN

The trademark of May & Baker, Ltd., for spiramycin is Rovamycin.

SOURCE Streptomyces ambofaciens, n. sp.

NATURE Amorphous base [1] .

MOLECULAR WEIGHT Approximately 450 (neut. equiv.) [1] .

OPTICAL ACTIVITY $[\alpha]_D^{20} = -80^{\circ}$[1] [1] .

UV ABSORPTION MAXIMUM 231 mμ [1] .

SOLUBILITY s. most organic solvents; sl. s. water. Sulfate: s. water, lower aliphatic alcohols.[1]

OTHER REACTIONS Analysis: C, 60.7; H, 9.0; N, 3.2; O, 27.1. Infrared[2]: 2968, 2930, 1735, 1453, 1375, 1162, 1122, 1085, 1070, 1055, 1017, 995 (recip. cm). Associated in culture liquors with congocidin, but latter does not

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/1/ c, 1 methanol. /2/ In carbon tetrachloride solution.

extract with methyl isobutyl-ketone or amyl acetate; 3 components by countercurrent distribution; resemblance to erythromycin and carbomycin.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Diplococcus pneumoniae, 0.2; Streptococcus pyogenes, 0.6; Gaffkya tetragena, Sarcina lutea, 0.8; Str. faecalis, 1.0; Str. viridans, 1.3; Micrococcus pyogenes var. aureus (including strains resistant to penicillin, chlortetracycline and other antibiotics), 1.4-3.5.[1] 114 strains of M. pyogenes var aureus resistant to penicillin or erythromycin were sensitive to spiramycin [3]. Inhibits (μg/ml) Neisseria meningitidis, 3; N. gonorrhoeae, 0.7; Hemophilus influenzae, 6-25; Alcaligenes faecalis, 6-50; Brucella bronchiseptica, 25-50; Pasteurella multocida, 25; Pseudomonas aeruginosa[1], >50.[2] Bacillus subtilis, Corynebacterium pseudodiphtheriticum, 3; N. catarrhalis, 10; Mycobacterium sp, 23; Escherichia coli, Aerobacter aerogenes, Klebsiella pneumoniae, 31-33. Proteus vulgaris resistant to 1500 μg/ml. Also active against rickettsiae.[1]

In vivo. Daily i.p. doses of 25 mg/kg for 5 days gave good protection in mice infected with D. pneumoniae; protection also afforded against M. pyogenes var. aureus and Str. pyogenes following treatment by i.p., s.c., or oral routes.[1] Daily parenteral doses of 300-400 mg/kg prolonged survival time in rabbits and mice with experimental toxoplasmosis. Appeared to be less effective than oxytetracycline in this experimental infection.[4]

CLINICAL Preliminary trials indicate favorable response in infections with M. pyogenes var. aureus (furunculosis, osteomyelitis, cardiovascular infections); also in nasopharyngeal, pulmonary, and septicemic infections, following oral doses of approximately 2 g/da. In some cases, total dosage up to 50 g was administered over a period of 20 days. One day of treatment appeared adequate in N. gonorrhoeae urethritis.[1] In other reports, infections caused by Str. pyogenes, M. pyogenes var. aureus, and H. influenzae responded less favorably to therapy. Good results obtained in bacterial pneumonia; a case of Klebsiella pneumonia failed to respond.[3, 5, 6] Average daily dose recommended for adults is 3 g/da in 3-4 oral doses at regular intervals over a 24-hour period, or 4-5 g/da in severe cases. For children the recommended dosage averages 50-100 mg/kg/da in 3-4 divided doses. Side effects were minimal.[3, 5, 6]

TOXICITY LD_{50} of sulfate salt in mice, 150-250 mg/kg, i.v.; 1500-2000 mg/kg, s.c. Oral doses of 5000 mg/kg were well tolerated[2]. In dogs, oral doses of 500 mg/kg/da for 4 weeks were non-toxic.[1]

In man, oral doses up to 4 g/da failed to induce side effects.[1]

RESISTANCE Cross resistance between bacterial strains resistant to spiramycin, erythromycin and carbomycin [1, 2].

ABSORPTION AND EXCRETION Following oral doses of 100-200 mg/kg in rabbits, peak blood concentrations of 4.4-14.7 μg/ml were noted in approximately 1 hour, with measurable levels in 8-24 hours. High levels in urine, but percentage of total dosage excreted by this route was low.[1]

In man, following 3 g per day administered orally in divided doses, blood levels averaged 2.7 μg/ml in 1 hour, and 1.6 μg/ml at 6 hours [2]. Peak serum levels of 1.0-6.7 μg/ml were obtained 2-4 hours after oral therapy [3].

290. STREPTOCARDIN

SOURCE Streptomyces sp, and Nocardia sp [1].

CRYSTAL FORM AND COLOR Brown needles [1].

UV ABSORPTION MAXIMA 365, 242-252 mμ[3] [1].

SOLUBILITY Acid form: s. many organic solvents, including alcohol, acetone, ether, ethyl acetate. Alkaline salts: s. water.[1]

QUANTITATIVE DETERMINATION Microbiological: Proteus vulgaris ATCC 7829 [1].

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis, 0.3-3.13; Bacillus subtilis, Pr. vulgaris, 0.39; Micrococcus pyogenes var. aureus, 1.56; Salmonella typhosa, 3.13; Escherichia coli, Pseudomonas aeruginosa, 12.5. Fungi: Aspergillus niger, Saccharomyces cerevisiae not sensitive to 25 μg/ml.[1]

TOXICITY Very toxic to mice. LD_{50} of Na salt, 12.5 mg/kg, i.v.[1]

291. STREPTOCIN

SOURCE Streptomyces griseus [1].

CRYSTAL FORM Needle-like crystals in rosettes [1].

UV ABSORPTION None characteristic [1].

/1/ In another report, Ps. aeruginosa is resistant to 1500 μg/ml. /2/ In another report, LD_{50} in mice was >5000 mg/kg, orally [5]. /3/ pH 6 phosphate buffer.

SOLUBILITY s. water, methanol, ethanol; i. chloroform.[1]

STABILITY Thermostable at pH 2.0-11.0 [1] .

OTHER REACTIONS Crystallizable from 1% glacial acetic acid in methanol or from acetone, but not from amyl acetate; forms gel in amyl acetate; crystalline structure lost on standing; sublimable.[1]

QUANTITATIVE DETERMINATION Microbiological: Trichomonas vaginalis [1] .

BIOLOGICAL ACTIVITY In vitro. High concentrations inhibit Bacillus subtilis, B. mycoides, Micrococcus pyogenes var. aureus, Mycobacterium avium, Mycobacterium sp. Inhibits T. vaginalis and T. foetus in dilutions of 1:20,000-1:29,000.[1]

TOXICITY LD_0 in mice, >800 mg/kg, i.v. [2] .

292. STREPTOGRAMIN

SOURCE Streptomyces graminofaciens, n. sp [1] .

NATURE Substantially neutral [1] .

MOLECULAR FORMULA $C_{26}H_{33}N_3O_7$ (approximately) [1] .

FORM Non-crystalline as yet [1] .

SOLUBILITY s. methanol, ethanol, acetone, ethyl acetate; sl. s. water, dilute, acid; i. ligroin.[1]

STABILITY Alkali treatment causes solution and rapid inactivation [1] .

OTHER REACTIONS Analysis: C, 62.25; H, 6.62; N, 8.42; S (trace impurity), 0.36; O, 22.35 (by diff.). Infrared: 2.98, 3.4, 5.73, 5.95, 6.14, 6.27, 6.8, 6.95, 7.2, 7.87, 8.12, 8.4, 8.52, 8.89, 9.45, 9.78, 10.21, 10.75, 10.98, 11.22, 11.46, 11.7, 12.25, 13.0, 13.40, 13.9, 14.3 μ.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Streptococcus pyogenes, 0.02; Hemophilus pertussis, 0.06; Micrococcus pyogenes var. aureus, 0.08; Bacillus subtilis, 0.66; Mycobacterium tuberculosis, 5.0; Brucella abortus, 15; Proteus vulgaris, 21; Escherichia coli, Salmonella typhosa, 85.[2]

In vivo. 50% protection in mice infected with Str. pyogenes afforded by 7 doses of 0.1 mg/kg, i.p., 5 mg/kg, i.m., or 44 mg/kg administered orally [2] . Administration by several routes also protected mice against M. pyogenes var. aureus [3] .

TOXICITY LD_{50} in mice, 450 mg/kg, i.p. [1] .

RESISTANCE Induction of resistance in vitro showed a slow stepwise pattern. A strain of M. pyogenes var. aureus originally sensitive to 0.2 μg/ml required 100 μg/ml for inhibition after 35 transfers in antibiotic-containing medium. No cross-resistance with penicillin.[1]

293. STREPTOGRAMIN-LIKE ANTIBIOTIC
(Antibiotic 899)

SOURCE Streptomyces sp resembling S. virginiae [1] .

NATURE Neutral [1] .

FORM AND COLOR Amorphous, reddish-yellow powder [1] .

MELTING POINT (°C) 115-120 [1] .

SOLUBILITY s. chloroform, methanol, ethanol; less s. methyl isobutyl ketone, benzene, amyl acetate; sl. s. water, ether; i. petroleum ether.[1]

STABILITY Loss after boiling 3 minutes: at pH 7, 10%; at pH 8, 100%; at pH 2, 75%.[1]

OTHER REACTIONS Same infrared and UV as streptogramin, but shows paper chromatographic differences [1] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Corynebacterium pseudotuberculosis, Diplococcus pneumoniae, Streptococcus pyogenes, 0.05-0.07; Sarcina lutea, 0.1; M. pyogenes var. aureus (including strains resistant to penicillin, streptomcyin, chloramphenicol, erythromycin and the tetracycline antibiotics), 0.2-0.3; Hemophilus

293. STREPTOGRAMIN-LIKE ANTIBIOTIC (Concluded)

pertussis, 0.4; Str. faecalis, 0.5; Bacillus subtilis, 1; Mycobacterium smegmatis, Myco. tuberculosis lacticola, 7; Myco. tuberculosis var. hominis (strain H37RV), 20. Aerobacter aerogenes and Candida albicans not sensitive to 100.[1]

In vivo. Two i.p. doses of 12.5 mg/kg protected mice against Str. pyogenes. No protection against Salmonella typhimurium infection.[1]

RESISTANCE Development of resistance follows the slow stepwise pattern characteristic for penicillin. No cross resistance with erythromycin. Complete cross resistance shown between this antibiotic and streptogramin.[1]

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294. STREPTOLINS

SOURCE Streptomyces sp [1] .

NATURE Polyacidic base [1] .

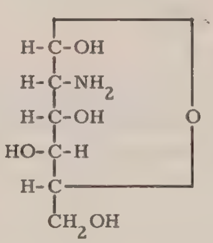
MOLECULAR FORMULA Streptolin A: $C_{17}H_{31}N_5O_8$ or $C_{24}H_{45}N_7O_{11}$[1] [2,3] .

MELTING POINT (°C) Streptolin A: 206 (d.) [2] .

OPTICAL ACTIVITY Streptolin AB HCl: $[\alpha]_D^{28} = -22°$[2], $-25°$[3].[1]
AB sulfate: $[\alpha]_D^{25} = -20°$[2].
A sulfate: $[\alpha]_D^{25} = -20°$[4].[2]

STABILITY Most stable at pH 3-3.5 [1] .

OTHER REACTIONS Streptolin A and B very similar; precipitated as helianthate and converted to hydrochloride; positive biuret, ninhydrin; reducing properties shown by the Shaffer-Somogyi copper reagent and by the Park and Johnson ferroferricyanide method; negative maltol, phenylhydrazine, 2,4-dinitrophenylhydrazine; <1% arginine; isolysine ($C_6H_{14}N_2O_2$) is an acid hydrolysis product derived from streptolin AB, viomycin and streptothricin[5]. [1,3,4] Acid hydrolysis produces (inter alia) CO_2, NH_3, L-β-lysine streptolidine, and the following amino sugar, which is also derived from streptothricin:



[6]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli [1-3] .

BIOLOGICAL ACTIVITY In vitro. Inhibit (in units/ml)[6] Fusobacterium plauti-vincenti, Bacillus megatherium, 0.1-0.3; B. polymyxa, E. coli, 1.0; Aerobacter aerogenes, B. cereus, Proteus sp, 3.3; B. mycoides, Pseudomonas aeruginosa, 10; Ps. fluorescens, 33.[1]

TOXICITY LD_{100} in mice, approximately 8-10 mg/kg, i.v. (deaths delayed 4-5 days) [1] . Streptolin A: LD_{100}, approximately 6 mg/kg, i.v. [2] .

RESISTANCE A number of bacteria show cross resistance to streptolin, streptomycin, streptothricin, and neomycin [5] .

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295. STREPTOLYDIGIN

The trademark of The Upjohn Company for streptolydigin is Portamycin.

SOURCE Streptomyces lydicus, n. sp [1] .

NATURE Strong enol acid [2] .

MOLECULAR FORMULA AND WEIGHT $C_{32}H_{46}N_2O_9$ or $C_{35}H_{50}N_2O_{10}$; 603, 658 (calc.); 675-685 (equiv. wt. found).[2]

CRYSTAL FORM Orthorhombic, acicular [2] .

/1/ Free base minimum formula. /2/ c, 1.8. /3/ c, 2.9. /4/ c, 1.0. /5/ Reactions for AB combination.
/6/ Approximately 33 units per µg.

295. STREPTOLYDIGIN (Concluded)

MELTING POINT (°C) Free acid: 144-150 [2] .

OPTICAL ACTIVITY Free acid: $[\alpha]_D^{25} = -65.7^{\circ 1}; -93^{\circ 2}; -76^{\circ 3}$.[2]

UV ABSORPTION MAXIMA 262, 291, 335 mμ^4; 357, 370 mμ^5.[2]

SOLUBILITY Free acid and Ca salt: s. most organic solvents; i. water, hydrocarbons. Na and K salts: s. organic solvents, water; i. hydrocarbons.[2]

STABILITY Alkali stable, acid labile [2] .

OTHER REACTIONS Positive $FeCl_3$, iodoform, titanium trichloride; negative reduction of 2, 6-dichlorophenol indophenol, Fehling, Molisch, biuret, ninhydrin; biologically inactive product when reacted with Br in CCl_4.[2]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Clostridium novyi, 0.04; Cl. tetanomorphum, Cl. perfringens, Cl. septicum, Diplococcus pneumoniae, Streptococcus pyogenes, 0.1-0.2; Str. mitis, 0.39; Cl. acetobutylicum, 1.6; Cl. botulinum, Erysipelothrix rhusiopathiae, Str. faecalis, Str. lactis, 3.12; Bacillus cereus, Listeria monocytogenes, Str. viridans, Mycobacterium ranae, Pasteurella multocida, 6.25; Myco. tuberculosis var. hominis, 6.25-15; Myco. phlei, Str. agalactiae, 12.5; B. subtilis, Bacteroides sp, Corynebacterium diphtheriae, Myco. smegmatis, 25; Micrococcus pyogenes var. aureus, 25-100; Neisseria catarrhalis, 50; Pseudomonas aeruginosa, Salmonella typhosa, 100. Several species of Shigella and Salmonella resistant to 100. Nocardia asteroides sensitive to 10 μg/ml. Fungi not sensitive, requiring 1000 μg or more for inhibition.[1]

In vivo. The median protective dosage in mice infected with Str. pyogenes was 95 mg/kg, s.c., and 220 mg/kg, in oral doses, daily for 6 days; against D. pneumoniae, 260 mg/kg, s.c., and 600 mg/kg, oral; against Past. multocida, 130 mg/kg, s.c., and 610 mg/kg, oral. Higher doses were ineffective against infections with M. pyogenes var. aureus, Klebsiella pneumoniae, S. typhosa, S. schottmuelleri.[3]

TOXICITY Maximum tolerated dose in mice (Na salt) was 400 mg/kg/da for 6 days by the subcutaneous route. Daily oral doses of 1000 mg/kg of Na salt and 1800 mg/kg/da of the free acid were well tolerated.[3]

RESISTANCE Development of resistance in vitro was rapid, resembling that characteristic of streptomycin rather than the one-step increases characteristic of penicillin. Streptococci showed no cross resistance between streptolydigin and the broad spectrum antibiotics.[3]

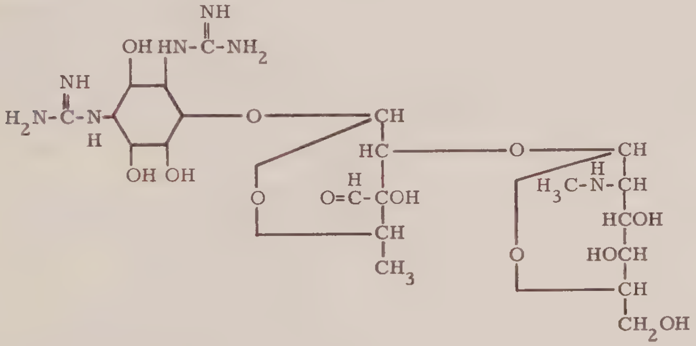
296. STREPTOMYCIN and DIHYDROSTREPTOMYCIN

SOURCE Streptomyces griseus [10] ; S. bikiniensis [11] ; S. mashuensis [12] .

NATURE Strong base [3, 6] .

MOLECULAR FORMULA $C_{21}H_{39}O_{12}N_7$ [3, 6] .

STRUCTURE



[2]

CRYSTAL FORM AND COLOR Reineckate: thin plates [7] . HCl: white amorphous powder [8] . Tri-HCl: monoclinic prisms [4] .

MELTING POINT (°C) Reineckate: 164-165 (d.) [7] . Helianthate: 220-226 (d.) [7] .

OPTICAL ACTIVITY HCl: $[\alpha]_D = -84^{\circ 6}$ [8] . Tri-HCl: $[\alpha]_D^{26.6} = -86.1^{\circ 7}$ [4] . Sulfate: $[\alpha]_D^{25} = -79^{\circ 7}$ [1] .

UV ABSORPTION End absorption only [8] .

/1/ c, 2.28% in 0.005N ethanolic KOH. /2/ c, 1.60% in chloroform. /3/ c, 1.78% in dioxane. /4/ In alkaline ethanol. /5/ In acid. /6/ c, 0.5 water. /7/ c, 1 water.

SOLUBILITY s. water; less s. lower alcohols; i. other organic solvents.[1, 3, 6]

STABILITY Stable at pH 3-7; less stable to heat, acid, alkali.[1, 3, 6]

OTHER REACTIONS Maltol produced by alkaline hydrolysis; inactivated by cysteine, reactivated by iodine; acid hydrolysis yields streptidine, streptobiosamine; positive Sakaguchi; react rapidly with carbonyl group reagents. [1, 3, 5, 6, 8]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli, Bacillus subtilis [1]. Maltol determination [3]. Colorimetric[1] [9].

BIOLOGICAL ACTIVITY Active against Gram-negative and Gram-positive bacteria, including mycobacteria; no activity against fungi, rickettsiae, and viruses. In vitro. Microorganisms vary considerably in their susceptibility, not only from one genus or species to another, but from strain to strain. In general, the most sensitive Gram-negative bacteria are species of Pasteurella, Salmonella, Klebsiella, Shigella, Hemophilus, and Brucella; the more susceptible Gram-positive organisms include species of Streptococcus and Micrococcus, Diplococcus pneumoniae, Corynebacterium diphtheriae, Bacillus anthracis, and Mycobacterium tuberculosis. Although freshly isolated cultures of Myco. tuberculosis from clinical cases are generally sensitive to low concentrations of the antibiotic, these organisms may rapidly acquire resistance in vitro; this also occurs with other bacteria. Dihydrostreptomycin has essentially the same activity as streptomycin, and both antibiotics exhibit reciprocal cross resistance.

In vivo. The activity in general follows the in vitro spectrum. Excellent protection is afforded by parenteral administration in a wide variety of experimental infections; these include Myco. tuberculosis, Br. abortus, Past. pestis, Past. tularensis, Neisseria meningitidis, B. anthracis, D. pneumoniae, Str. pyogenes, M. pyogenes var. aureus, and species of Salmonella, Shigella, Klebsiella, Hemophilus, and Pseudomonas.

CLINICAL Streptomycin and dihydrostreptomycin have been used with success in tuberculosis and in a variety of infections caused by Gram-negative and Gram-positive bacteria. The main non-tuberculous conditions which have responded favorably to therapy, include bacteremia, meningitis, and urinary tract infections caused by sensitive bacteria; pneumonia caused by K. pneumoniae; empyema and other pulmonary conditions caused by susceptible strains; chancroid, tularemia, plague, glanders, wounds and skin infections caused by Pr. vulgaris; peritonitis and enteritis, corneal ulcers caused by Ps. aeruginosa; also valuable for prophylaxis in bowel surgery. The emergence of resistant strains has been increasingly noted, e.g., the majority of strains of Pr. vulgaris, Ps. aeruginosa, Aerobacter aerogenes, and Str. faecalis, now being clinically isolated, are resistant to these antibiotics. For this reason their use is generally limited to infections in which the responsible agent is shown to be sensitive by laboratory tests. Favorable results have been obtained in systemic infections with streptomycin in combination with other drugs, e.g., with penicillin in mixed infections of the urinary tract, and with one of the tetracyclines and/or sulfadiazine in brucellosis and glanders. In pulmonary and certain other forms of tuberculosis, streptomycin therapy combined with PAS (p-aminosalicylic acid), or with isoniazid (isonicotinic acid hydrazid) and related compounds, has been highly successful. Streptomycin (or dihydrostreptomycin) is generally administered i.m. daily, 1-2 g in divided doses every 6 hours, or in severe infections 2-4 g/da for 2-3 days. In pulmonary tuberculosis, doses of 1 g 2-3 times weekly in conjunction with PAS or isoniazid, for periods of approximately 120 days, have been recommended. In tuberculous meningitis, daily i.m. doses of 2 g or more have been administered, and this has been supplemented with intrathecal doses of approximately 50 mg on alternate days. Streptomycin has been administered intravenously, but this route is seldom recommended and should never be used for dihydrostreptomycin. In view of the ototoxic and neurotoxic capacity of either drug, it has been recommended that audiometric and vestibular function tests be frequently made in patients under therapy. Following oral administration, or inhalation as aerosol, there is practically no absorption and the bulk of the dose is excreted in the feces. Oral doses are well tolerated without side effects, hence this method is useful in the treatment of gastrointestinal infection or in preparation for surgical procedures on the colon. Topical therapy has proved effective in a variety of local infections. Dihydrostreptomycin has been favored for topical use in view of the fairly high incidence of sensitization following local use of streptomycin.

VETERINARY Useful in infections caused by susceptible organisms, e.g., in bovine vibriosis, calf pneumonia, mastitis, navel ill in foals, canine leptospirosis, distemper complex, dysentery and peritonitis, swine enteritis, sinusitis in turkeys, and other conditions.

ACUTE TOXICITY LD_{50} in mice, approximately 200 mg/kg, i.v.; 900 mg/kg, s.c.; 9000 mg/kg, oral.

In vitro. Low toxicity in tissue cultures; 2200-6600 μg/ml required to inhibit skin, and >300 mg/ml for inhibition of outgrowth of spleen tissue.

CHRONIC TOXICITY Mice tolerate up to 1000 mg/kg/da in divided doses for 6 days by s.c. route, and 1500 mg/kg/da in the diet. Repeated high doses were well tolerated by rats, monkeys, and other animals.

In man, streptomycin and dihydrostreptomycin are of low toxicity, and although untoward reactions are occasionally observed these are rarely severe. Minor effects consist of skin rash, malaise, drug fever and eosinophilia. Incidence of severe renal complications is low. Neurotoxic action on eighth cranial nerve is of particular importance during prolonged therapy, e.g., symptoms of vertigo, tinnitus, atoxia and diminished acuity of hearing are watched for. Recovery from these effects after discontinuation of therapy may be slow and occasionally incomplete. Streptomycin appears to be less toxic to the auditory branch of the 8th cranial nerve, and dihydrostreptomycin less toxic to the vestibular branch of this nerve.

/1/ Assay for dihydrostreptomycin based on reaction between guanido materials and diacetyl, alkali and α-naphthol.

296. STREPTOMYCIN and DIHYDROSTREPTOMYCIN (Concluded)

ABSORPTION AND EXCRETION Readily absorbed and excreted following i.m. administration in man, with peak serum concentrations in 1 hour decreasing at a uniform and relatively rapid rate. Approximately 50-75% of the total dose is excreted in the urine within 24-hour period; high levels in the bile. Readily diffuse through the placenta; very little diffusion into cerebrospinal fluid, although therapeutic concentrations are obtained in presence of inflamed meninges. Practically no absorption following oral administration; hence this route is of no value in the treatment of systemic infections, but is useful in gastrointestinal infections.

RESISTANCE Strains of Myco. tuberculosis and other organisms may develop resistance to streptomycin (or dihydrostreptomycin) very rapidly. Development in vitro of dependent strains which require the antibiotic for growth has been described; this suggests that these strains may utilize the antibiotic as an essential nutrient. Bacteria may develop resistance either gradually through a series of changes, or in a single step, the result of a single genetic change which produces a resistant variant.

MODE OF ACTION Bacteriostatic and bactericidal. Inhibit oxaloacetate-pyruvate condensation which is essential to oxidation energy processes of E. coli. Interfere with the complete oxidation of fatty acid by Myco. tuberculosis.

ANIMAL NUTRITION As feed supplement, antibiotic shows growth-promoting effect in chicks and pigs.

PHYTOPATHOLOGY Streptomycin has given good protection in bacterial diseases of plants, e.g., bacterial spot of tomato, fire blight of apple and pear, cucumber leaf spot, wildfire of tobacco, wilt of chrysanthemum; also blue mold disease of tobacco.

297. STREPTOTHRICIN

SOURCE Streptomyces lavendulae, and other Streptomyces spp [6, 29, 30] .

NATURE Basic [2] .

MOLECULAR FORMULA $C_{13}H_{25}O_7N_5$ [2] , or $C_{20}H_{34}O_9N_8$ (proposed) [4, 5] .

CRYSTAL FORM AND COLOR HCl: white powder [1] . Sulfate: white powder [2] . Reineckate: fine platelets in clusters [2] .

MELTING POINT (°C) Reineckate: 192-194 (d.) [2] . Helianthate: 220-230 (d.) [1, 3] .

OPTICAL ACTIVITY HCl: $[\alpha]_D^{25} = -51.3^{\circ}$[1] [1] .

UV ABSORPTION End absorption only [2] .

SOLUBILITY HCl: s. water, dilute mineral acids; i. ether, petroleum ether, chloroform.[1, 2]

STABILITY Stable at pH 1-8.5; thermolabile in culture filtrate, especially at alkaline pH.[1, 2]

OTHER REACTIONS Destroyed by concentrated acids; not digested by proteolytic enzymes; reduces Tollens, neutral permanganate, boiling Fehling; positive biuret, ninhydrin, Pauly; negative $FeCl_3$, nitroprusside, Molisch, Sakaguchi, Schiff, Hopkins-Cole, Millon; activity unaffected by cysteine; compound A (β-ε-diaminocaproic acid) was isolated and also appears in streptolin and viomycin[2].[1, 5] In common with streptolin, acid hydrolysis yields (inter alia) CO_2, NH_3, L-β-lysine, streptolidine, and an amino sugar[3] [32] .

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis [1] .

BIOLOGICAL ACTIVITY Active against Gram-positive and Gram-negative bacteria and certain fungi. In vitro. Inhibits (units/ml) Micrococcus lysodeikticus, Salmonella typhosa, S. gallinarum, 1; M. pyogenes var. aureus, Micrococcus spp, S. paratyphi, S. schottmuelleri, Shigella spp, Mycobacterium avium, Myco. smegmatis, 2.5-5.0; Escherichia coli, 2.5-20; Sarcina lutea, 10; Diplococcus pneumoniae, 30; Myco. tuberculosis, 1-250. Aerobacter aerogenes, Shigella dysenteriae, Sh. paradysenteriae, Myco. phlei, B. subtilis are sensitive; B. cereus, B. mycoides, Pseudomonas aeruginosa, Ps. fluorescens are resistant.[7-10] Yeasts and fungi: Coccidioides immitis, 1; Dipodascus uninucleatus, 1.25; Rhodotorula rubra, 20; Saccharomyces cerevisiae, 80; Candida albicans, C. stellatoidea, >160; Blastomyces dermatitidis, Rhizopus nigricans, 10; Penicillium notatum, 30; Trichophyton schoenleinii, 100; T. interdigitale, 300; T. mentagrophytes, Aspergillus flavus, Mucor sulfa, Neurospora ascospora, >300.[7] Concentration of 25 μg/ml inhibits the protozoan, Trichomonas vaginalis [26] .

In vivo. Active against Brucella abortus in chick embryos and guinea pigs [11] . Single or repeated doses of 50-300 units by i.v., i.p., or s.c. routes gave good protection in mice infected with S. schottmuelleri, S. typhosa, Sh. dysenteriae, E. coli, and little or no protection against Proteus vulgaris, Ps. aeruginosa, Streptococcus pyogenes, D. pneumoniae, and Pasteurella pestis [12, 13, 18] . High activity in mice infected with Past. tularensis following parenteral injection of 10,000 units/kg/da [27] ; no activity in experimental tuberculosis of guinea pigs or hamsters [16, 17] . When included in the diet, 30,000 units/da for 3-4 days reduced number of coliform bacteria in the feces of mice [9] . Suppressed Bl. dermatitidis in chick embryos [14] . No activity against viruses of

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/1/ c, 1.4 water. /2/ Streptothricin B I [33] is probably neomycin C, and B II [34] , neomycin B. /3/ See streptolin for formula.

influenza, lymphogranuloma venereum or feline pneumonitis in mice or embryonated eggs, or against the protozoa Trypanosoma equiperdum in mice and Plasmodium gallinaceum in chicks [9, 12, 15, 19] .

ACUTE TOXICITY Wide variations in toxicity of preparations, depending on purity. Purer preparations of 250-530 units/mg were fairly toxic; LD_{50} in mice, 86,000-131,000 units/kg, i.v. Delayed deaths at higher doses.[20]

CHRONIC TOXICITY Daily s.c. doses up to 5000 units/kg for 1 month were tolerated in mice and rats; repeated doses of 10,000 units induced hematuria, anuria, and were eventually lethal. Daily i.v. amounts of >2500 units/kg for 7 days lethal to dogs; 5000 units/kg/da administered s.c. for 1 month, lethal to guinea pigs [21] . Diets containing 5000 units/100 g food well tolerated in chicks, but levels of 10,000 units were toxic [23] . In mice after i.v. administration, lesions observed in renal tubules, liver and nervous system; also intestinal and cardiovascular changes noted [20] . Severe fatty and necrotic histopathologic changes in the liver have been described [22] .

ABSORPTION AND EXCRETION Rapidly excreted in the urine 5-6 hours after parenteral injection in experimental animals, and approximately 10% excreted in the bile. In dogs, 15,000 units/kg/da in divided doses every 3 hours produced peak serum concentrations of 2-5 units/ml.[21] Like streptomycin, this antibiotic was poorly absorbed from the gastrointestinal tract following oral administration [12] .

RESISTANCE In vitro. Resistance develops fairly readily [24] . Resistant strains frequently display cross resistance to streptomycin and neomycin [25] .

PHYTOPATHOLOGY Effective (superior to penicillin) in control of crown gall disease in plants [28] . When primary older leaves of pinto bean plants were sprayed with streptothricin, the young untreated trifoliate leaves were protected from blight caused by Xanthomonas phaseoli. When sprayed on intermediate leaves of tobacco, tomato, and bean plants, the antibiotic was readily absorbed and transported up stem to young leaves as well as downward to older untreated leaves; in some cases translocation to roots occurred. The antibiotic caused injury to treated leaves in the form of necrotic spots.[31]

298. STREPTOTHRICIN TYPE 3

Related to, but not identical with, neomycin.

SOURCE Streptomyces sp resembling S. flavus [1] .

MELTING POINT (°C) Reineckate: 172-178 (d.) [1] . Helianthate: 208-211 (d.) [1] .

STABILITY Thermolabile at alkaline pH, e.g., 95% loss at pH 9 [1] .

OTHER REACTIONS Culture also produces flavacid; positive Molisch, glucosamine; negative ninhydrin.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Brucella melitensis, 0.75; Bacillus anthracis, 1.5; Streptococcus pyogenes, Str. viridans, Shigella sonnei, 3; M. pyogenes var. aureus, 3-6; Mycobacterium spp, 3-12; Neisseria meningitidis, Salmonella typhosa, S. paratyphi, Klebsiella pneumoniae, B. subtilis, 6; Diplococcus pneumoniae, S. schottmuelleri, Vibrio comma, Escherichia coli, 12; E. coli (streptomycin-resistant strains), 6-96; Myco. tuberculosis var. hominis, 30; Pseudomonas aeruginosa, >96.[1]

TOXICITY LD_{50} in mice, approximately 100 mg/kg, i.v. (deaths delayed 3-7 days) [1] .

299. SUBTENOLIN

SOURCE Bacillus subtilis [1] .

FORM AND COLOR Light yellow powder, somewhat hygroscopic [2] .

UV ABSORPTION Only end absorption, 270 mμ [2, 3] .

SOLUBILITY s. water, ethylene glycol, 95% methanol, some other wet organic solvents; i. acetone, butanone, ether, 95% ethanol, methyl ethyl ketone.[2, 3]

STABILITY Thermostable; loses activity on drying in presence of water.[2]

OTHER REACTIONS Activity destroyed by H_2S but not by trypsin; not precipitated by acids or alkalies; positive peroxidase, Molisch, Benedict; negative biuret, Millon, Hopkins-Cole, trichloroacetic acid, $FeCl_3$, enol, p-phenylenediamine; slight purple with ninhydrin[1]; reduces permanganate; I, Br, ammoniacal $AgNO_3$, Shaffer-Somogyi sugar reagent; brown solution and rosette crystals with picric acid; dialyzable. Analysis: C, 51.4; H, 7.00; N, 7.88; S, 0.81.[2, 3]

/1/ Reference 2, in contrast, lists positive $FeCl_3$, enol, ninhydrin.

299. SUBTENOLIN (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (µg/ml) Pasteurella pestis, 16; Pasteurella sp, 22.5; M. pyogenes var. aureus, 140-200; Salmonella typhosa, 165; Streptococcus sp, 375; Clostridium spp, 300-600; Neisseria gonorrhoeae, S. schottmuelleri, 600; Escherichia coli, 370-1500; Str. pyogenes, 1500. A variety of organisms including Bacillus subtilis, B. anthracis, Diplococcus pneumoniae, Brucella spp, Mycobacterium tuberculosis, Klebsiella pneumoniae and certain strains of M. pyogenes var. aureus, are highly resistant.[1]

In vivo. No activity in chicks infected with Plasmodium gallinaceum following i.p. doses of 200 mg/kg/da [4] .

PHARMACOLOGY LD_{50} in mice, 30-60 mg, i.p. Appeared in the urine 15 minutes after injection, with 30-50% of total dose excreted within 10 hours.[1]

300. SUBTILIN

SOURCE Bacillus subtilis [1] .

NATURE Basic polypeptide [2] .

MOLECULAR WEIGHT 3420 (average found); 3188 (calc.).[3]

FORM AND COLOR Amorphous white powder [2] .

OPTICAL ACTIVITY $[\alpha]_D^{23} = -29.0$ to -35.0°[1] [2] .

SOLUBILITY s. water, water-saturated n-butanol, 0-80% ethanol, methanol, acetic acid; i. anhydrous ethanol, butanol, amyl alcohol, acetone, ether, petroleum ether, chloroform.[2]

STABILITY Stable, especially at pH 2.5; dry preparations relatively unstable at room temperature.[1, 2]

OTHER REACTIONS Incomplete empirical formula: glycine$_2$ alanine$_1$ valine$_1$ leucine$_4$ isoleucine$_1$ proline$_1$-phenylalanine$_1$ tryptophan$_1$ lysine$_3$ asparagine$_1$ glutamic acid$_3$ lanthionine$_1$ $(C_7H_{12}O_3N_2S)_4$ (amide)$_5$ H_2O; inactivated by light, alkali, pepsin, trypsin, methanol, formaldehyde; blue with $FeCl_3$; dialyzable; solubility in acid solution decreased by salt [2, 3] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus. $FeCl_3$ color reaction[2]. [1]

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus, M. conglomeratus, Streptococcus pyogenes, Str. viridans, Lactobacillus casei, Bacillus anthracis, Diplococcus pneumoniae, Neisseria gonorrhoeae [1, 4] . Mycobacterium tuberculosis inhibited by dilution of 1:50,000, but only in the presence of surfactant Tween 80 in culture medium [4, 5] . Gram-negative bacteria (except N. gonorrhoeae) not susceptible. Yeasts and fungi: Candida albicans, Cryptococcus neoformans, Sporotrichum schenckii, Trichophyton mentagrophytes sensitive.[4] Spirochetes and protozoa: Inhibits Trypanosoma equiperdum in dilution of 1:2000; T. cruzi, 1:200; Entamoeba histolytica, 1:400,000; Borrelia duttoni, 1:2800; Treponema pallidum, 1:300,000-1:500,000; Leptospira icterohemorrhagiae and Leishmania donovani not sensitive.[6-9, 15] Active against a variety of bacteriophages [10] .

In vivo. Active in experimental mouse infections with Str. pyogenes, D. pneumoniae, M. pyogenes var. aureus, B. anthracis. A modified serum-soluble fraction showed activity in experimental tuberculosis in guinea pigs following s.c. doses of 22 mg/kg/da.[11] Low doses of 0.4 mg/kg suppressed experimental relapsing fever (Borrelia duttoni); 2.5-16.0 mg/kg doses sterilized this infection in mice.[12, 15] No effect on Treponema pallidum infection in rabbits [6] , Trypanosoma equiperdum and T. cruzi in mice [7, 8] , Leptospira icterohemorrhagiae in guinea pigs [9] , or Plasmodium gallinaceum in chicks [16] . Inactivated influenza PR-8 and Newcastle disease virus in embryonated eggs [14] . Rickettsiostatic activity in chick embryos against Rickettsia tsutsugamushi; less effective against R. rickettsi.[17]

VETERINARY Instillation of amounts up to 0.4 g in each udder quarter in cases of bovine mastitis failed appreciably to eliminate streptococcal infection [30] .

TOXICITY LD_{50} in mice, approximately 60 mg/kg, i.v.; 670 mg/kg, s.c. Oral doses of 5000 mg/kg were lethal. [7] Rats fed 0.1% antibiotic in the diet for 220 days showed no untoward effects and no significant histopathologic changes. Subtilin administered parenterally was precipitated in the tissues.[18] In vitro. Partially purified preparations showed low toxicity in embryonic chick heart tissue cultures; exposure to concentrations as high as 0.2% for 10 minutes were required to stop proliferation.[28]

RESISTANCE Strains of M. pyogenes var. aureus, Myco. phlei, and E. coli readily developed resistance after serial transfers in medium containing antibiotic [4] ; M. pyogenes var. aureus and Myco. phlei developed a 250 to 400-fold resistance after 6-9 serial transfers in increasing concentrations of the antibiotic [31] . A virulent strain of M. pyogenes var. aureus showed a 50-fold increase in resistance following only 2 serial exposures to subtilin [37] .

/1/ c, 1 acetic acid. /2/ May or may not be active molecule.

300. SUBTILIN (Concluded)

ABSORPTION AND EXCRETION Intravenous administration in rabbits produced blood levels of 100-200 ppm which dropped to 10-30 ppm in 2 hours, with no detectable concentrations in 24 hours. As much as 7% of the administered dose was recovered in the urine within 2 hours.[29]

MODE OF ACTION Bactericidal action similar to that of tyrocidin and surfactants; hence suggested this antibiotic be included in the surfactant class of germicidal agents [19] . In relatively high concentrations subtilin lyzed Trypanosoma equiperdum, Treponema pallidum, and Borrelia duttoni. Concentrations in excess of those required for growth inhibition induced changes in morphology and staining properties of M. pyogenes var. aureus, Escherichia coli, and B. anthracis.[32] Primarily sporostatic rather than lethal to spores of B. macerans which multiplied following inactivation of the antibiotic with trypsin [38] .

ANIMAL NUTRITION When used as feed supplement, subtilin gave good growth response in chicks [22] .

MISCELLANEOUS Usefulness as food preservative suggested in view of report that spores of Clostridium botulinum were less resistant to heat when suspended in food containing small amount of antibiotic [20] . Action on Cl. botulinum, types A and B, was sporostatic rather than sporocidal [21] . Subtilin controlled growth of experimentally added micrococci in custard fillings [23] , and, when combined with oxytetracycline, also enterococci and salmonella [24] . Good control in experimental infection of barley seedlings with seed pathogen, Xanthomonas translucens [13] . Vaccines prepared by inactivation of Newcastle disease virus with this antibiotic were effective in immunization of chicks [25] . Certain derivatives of subtilin were more active in vitro than parent antibiotic against Myco. tuberculosis, Str. faecalis, and other bacteria [26, 27] . Methyl and hydroxyethyl esters of the antibiotic were more soluble and showed 2-4 times greater in vitro bacteriostatic activity; ethyl and hydroxypropyl esters were as active as the parent antibiotic.[33] In concentrations of 0.01-1.0 ppm, subtilin inhibited lactic streptococci in starter cultures used in cheddar cheese-making [34] . The antibiotic was of no value in preventing development of American foul brood, a bacterial disease of honeybee colonies [35] . High concentrations (100-1000 ppm) delayed, but did not prevent, spoilage in comminuted beef inoculated with 100 or 10, 000 spores of a putrefactive anaerobic bacterium [36] .

301. SULFACTIN

SOURCE Streptomyces roseus [1] .

MOLECULAR FORMULA $C_{38}H_{55}O_7N_{11}S_4$ or $C_{27}H_{40}O_5N_8S_3$ (proposed) [1] .

CRYSTAL FORM AND COLOR Needles; white double pyramids.[1]

MELTING POINT (°C) 245-275 (d. corr.) [1] .

SOLUBILITY s. chloroform, ethanol, ethyl acetate, dioxane, n-butanol; sl. s. methanol; i. water, ether, petroleum ether, benzene.[1]

STABILITY Stable in boiling alcohol; less stable in boiling neutralized culture filtrates.[1]

OTHER REACTIONS Dialyzable, but loses activity; reduces Fehling, permanganate; negative Sakaguchi, Molisch, biuret, $FeCl_3$; hygroscopic.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (units/ml)[1]; Corynebacterium diphtheriae, 0.03; C. xerose, 0.06; M. lysodeikticus, M. aurantiacus, 0.25; Diplococcus pneumoniae, Bacillus mesentericus, Neisseria sicca, 0.5; B. subtilis, 0.5-4.0; B. mycoides, 0.5-16.0; Gaffkya tetragena, 0.5-8.0; M. pyogenes var. aureus, 1.0; B. circulans, B. megatherium, 2; Streptococcus pyogenes, 4; B. anthracis, 8-16; B. cereus, 16; Str. viridans, 32. Gram-negative bacteria not sensitive to 32 units/ml include Aerobacter aerogenes, Brucella spp, Escherichia coli, Klebsiella pneumoniae, Neisseria catarrhalis, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella spp, Shigella spp. Also resistant to 32 units/ml: Sarcina lutea, Str. faecalis, Mycobacterium smegmatis. Activity reduced by serum.[2]

In vivo. Doses of 1-10 µg, i.p., protected mice against infection with D. pneumoniae [2] .

TOXICITY LD_{50} in mice, 135 mg/kg, i.p. Liver enlargement noted following doses of 50 mg/kg.[2]

302. SYNNEMATINS

SOURCE Cephalosporium salmosynnematum [1] .

SOLUBILITY s. water, methanol, aqueous acetone, aqueous ethanol; i. ethanol, acetone, ether.[1, 3]

STABILITY Thermo- and acid labile; stable at 11 months at 5°C dried, but loses activity in 17 months.[1, 3]

OTHER REACTIONS More active at acid pH; activity reduced in presence of serum; by paper chromatography with buffered methanol, component A remains at point of application, B moves.[1-3] Synnematin B may be identical with cephalosporin N.[8, 9]

/1/ 1 unit = approximately 0.025 µg.

302. SYNNEMATINS (Concluded)

QUANTITATIVE DETERMINATION Microbiological: Salmonella typhimurium [1-3] .

BIOLOGICAL ACTIVITY In vitro. Inhibit (units/ml)[1] Corynebacterium diphtheriae, 0.25; S. typhosa, S. pullorum, 0.5; Brucella melitensis, Br. suis, Diplococcus pneumoniae, Proteus sp, S. choleraesuis, S. enteritidis, S. paratyphi, S. schottmuelleri, S. typhimurium, Micrococcus pyogenes var. aureus, Mycobacterium phlei, 1-2; Streptococcus pyogenes, 1-32; Br. abortus, 2; Bacillus subtilis, 8; Shigella alkalescens, 4-16; Sh. paradysenteriae, 8-64; Sh. dysenteriae, 32; Escherichia coli, 32->64; Myco. tuberculosis, >12; Klebsiella pneumoniae, Pseudomonas aeruginosa, >32. Fungi not sensitive (>32 units/ml).[1]

Synnematin A: Active against Pr. vulgaris, Sarcina lutea, Salmonella typhimurium; low activity against B. subtilis, M. pyogenes var. aureus.[2]

B: Very active against Pr. vulgaris, Sarcina lutea; no activity against B. subtilis, M. pyogenes var. aureus. [2] Inhibited 40 strains of Salmonella typhosa at concentrations of 1.2-5.0 μg/ml [4] . Activity reduced by 50% in presence of serum [1] .

In vivo. Single s.c. dose protected mice infected with D. pneumoniae; also active against S. pullorum in chick embryos.[1]

Synnematin B: Thirty s.c. injections of 25 units eliminated S. typhimurium from mice; also effective against infections with S. typhosa.[5] S.c. doses of 40-80 mg/kg every 3 or 12 hours protected guinea pigs infected with Leptospira icterohemorrhagiae [10] . Chicks freed of S. pullorum after total doses of 1500-6000 units; the preparations used in these animal tests assayed 40-100 units/mg [5] . Ineffective against experimental toxoplasmosis in mice treated with s.c. doses of 5 mg every 12 hours [6] .

CLINICAL Preliminary trial in 15 patients with typhoid fever showed generally favorable clinical response with 3 relapses. No carrier state during therapy; blood and feces cleared of S. typhosa. Preparations used contained approximately 25% pure synnematin B; 80-350 mg/kg/da of whole drug (20-87.5 mg/kg/da pure synnematin B) was administered i.m. for 9-14 days, with no notable untoward reactions.[7]

TOXICITY Mice tolerated 5000 mg/kg (160,000 units/kg), i.p., of synnematin B [1] . Weanling rats tolerated daily parenteral doses of 1000 mg (50,000 units/kg) of B for 21 days; no effect on weight gains and no histopathologic changes noted.[5]

In man, i.m. doses of 20-87.5 mg/kg/da of synnematin B were well tolerated [7] .

ABSORPTION AND EXCRETION Detectable blood concentrations in 2 hours after i.m. administration in man. Rapidly excreted in the urine in 4-hour period between injections.[7]

303. TARDIN

SOURCE Penicillium tardum [1] .

MOLECULAR FORMULA $C_{11}H_{15}O_3$ (proposed) [1] .

FORM AND COLOR Pale yellow oil [1] .

OPTICAL ACTIVITY $[\alpha]^{20}_{D} = -11.4^{\circ}$[2] [1] .

SOLUBILITY s. alcohol, acetone, ether, benzene, amyl acetate; sl.s. water, warm hexane [1] .

STABILITY Stable at pH 2.8, unstable above 8 [1] .

OTHER REACTIONS Purple color with $FeCl_3$, brown on warming; negative 2,4-dinitrophenylhydrazine; yields an acid and neutral fraction on decomposition or acid hydrolysis.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus in dilution of 1:128,000; Corynebacterium xerose, 1:64,000; C. diphtheriae, Streptococcus viridans, 1:8000; Salmonella enteritidis, 1:1000. Escherichia coli, Pseudomonas aeruginosa not sensitive to 1:1000. Fungi: Microsporum audouini, M. canis, Trichophyton equinum inhibited by 1:5000 dilution.[1]

PHARMACOLOGY Mice tolerated 40 mg/kg, i.v., and 125 mg/kg, s.c. Low solubility precluded higher dosages. Skin over site of s.c. injection sloughed. Isolated guinea pig uterus showed increased contraction, followed by cessation, in 1:25,000 solution. Same concentration perfused through heart produced complete stoppage in 9 minutes. In vitro. 1:16,000 showed no effect on human leukocytes; dilution of 1:2000 lethal in 30 minutes.[1]

304. TERRECIN

SOURCE Aspergillus terreus [1] .

CRYSTAL FORM AND COLOR Light yellow prisms [1] .

/1/ Preparations for in vitro tests contained 32 units/mg. /2/ Alcohol.

304. TERRECIN (Concluded)

MELTING POINT (°C) 219-220 [1] .

SOLUBILITY s. acetone, ether, alcohol, benzene, Na_2CO_3, NaOH [1] .

STABILITY Thermostable 10 minutes, unstable 30 minutes, at 100°C [1] .

OTHER REACTIONS Analysis: C, 51.89, H, 3.51; N, 3.8, Cl, 19.1; yellow in solution; precipitated by addition of acid when in alkaline solution; deep violet with $FeCl_3$; not hygroscopic.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209-P [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Clostridium tetani, 0.025-0.2; Cl. perfringens, 0.05-0.2; Bacillus anthracis, 1.0; Streptococcus pyogenes, Neisseria gonorrhoeae, 1.25; Diplococcus pneumoniae, 2.5; M. pyogenes var. aureus, 5.0; Salmonella typhosa, 1000; Escherichia coli, >500.[1]

TOXICITY Mice tolerated 1000 mg/kg, i.p. [1] .

305. TERREIC ACID

SOURCE Aspergillus terreus [1] .

MOLECULAR FORMULA AND WEIGHT $C_7H_6O_4$ [1,2] ; 154, 157 (equiv. wt. found).[2]

CRYSTAL FORM AND COLOR Colorless plates [1] ; pale yellow, large, glistening plates [2] .

MELTING POINT (°C) 120-121 [1] ; 127-127.5 [2] .

OPTICAL ACTIVITY $[\alpha]^{22}_{D} = -16.6^{\circ 1}, -28.6^{\circ 2}, +74.3^{\circ 3}$.[2]

UV ABSORPTION MAXIMA 213, 316 mμ [2] .

SOLUBILITY s. ether, benzene, alcohol, acetone, hot cyclohexane; sl. s. water, hexane.[1,2]

STABILITY Thermo- and alkali labile; acid stable; thermostable in solid form.[1,2]

OTHER REACTIONS pKa about 4.0-4.5; forms bright yellow salts; deep red color with $FeCl_3$; reduces Fehling and ammoniacal $AgNO_3$; precipitate with 2,4-dinitrophenylhydrazine.[1,2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Proteus vulgaris, 3.1; M. pyogenes var. aureus, Salmonella typhosa, 25; Klebsiella pneumoniae, Escherichia coli, 50.[2] Streptococcus pyogenes and Pseudomonas aeruginosa inhibited by dilutions of 1:5,000-1:10,000 [1] . Candida albicans and Trichophyton mentagrophytes sensitive to 100-400 μg/ml.[2]

In vivo. No activity in mice infected with Diplococcus pneumoniae or K. pneumoniae [2] .

TOXICITY LD_{50} in mice, 71-119 mg/kg, i.v. Inhalation of vapor during sublimation irritating to human nasopharynx.[2]

306. TERTIOMYCIN A

Formerly named Tertiomycin [2] .

SOURCE Streptomyces eurocidicus [1] .

CRYSTAL FORM AND COLOR White needles [1] .

MELTING POINT (°C) 202-204 (d.) [1] .

OPTICAL ACTIVITY $[\alpha]^{17}_{D} = -44^{\circ 4}, -49^{\circ 1}$.[1]

UV ABSORPTION MAXIMUM 233 mμ^5 [1] .

SOLUBILITY s. methanol, ethanol, butanol, ethyl acetate, butyl acetate, ether, dioxane, ethyl cellosolve, chloroform, acetone; i. water, petroleum ether.[1]

OTHER REACTIONS Analysis: C, 60.10, 60.09, 59.85; H, 8.45, 8.40, 8.18; N, 2.49, 2.79, 2.26, 2.45; negative ninhydrin, biuret, Benedict, Sakaguchi, xanthoproteic, $FeCl_3$, maltol, Fehling; positive Molisch, Seliwanoff; reddish orange in 40% H_2SO_4; belongs to erythromycin-carbomycin antibiotic group.[1]

/1/ c, 1 chloroform. /2/ c, 1 50% CH_3OH - 50% C_6H_6. /3/ c, 1 phosphate buffer at pH 7. /4/ c, 1 ethanol. /5/ Ethanol.

306. TERTIOMYCIN A (Concluded)

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus flavus, Bacillus anthracis, B. megatherium, 0.1; M. pyogenes var. aureus, Sarcina lutea, 0.5; B. subtilis, 1.5. Gram-negative bacteria, mycobacteria, and fungi not sensitive to 100 μg/ml: Escherichia coli, Shigella dysenteriae, Salmonella paratyphi, Pseudomonas aeruginosa, Mycobacterium tuberculosis, Myco. phlei, Aspergillus niger, and Candida albicans.[1]

TOXICITY Mice tolerated 415 mg/kg, i.p. [1] .

307. TERTIOMYCIN B

SOURCE Streptomyces eurocidicus[1] [1] .

MOLECULAR FORMULA $C_{43}H_{71}NO_{17}$ (proposed) [1] .

CRYSTAL FORM AND COLOR White needles[2] [1] .

MELTING POINT ($^{\circ}$C) 97-99 [1] .

OPTICAL ACTIVITY $[\alpha]^{22}_{D} = -56^{\circ}$[3] [1] .

UV ABSORPTION MAXIMA 231, 278 mμ [1] .

OTHER REACTIONS Carbomycin type; positive Tollens, Molisch; negative Fehling, ninhydrin, Liebermann, $FeCl_3$; added to 6 N HCl gives no color at room temperature, but turns brownish violet on heating; light reddish brown color with 40% H_2SO_4. R_f values: 0.08 with citrate buffer at pH 4.6 and benzene, 0.85 with citrate buffer at pH 4.0 and butyl acetate. Analysis: C, 59.1; H, 8.26; N, 1.62.[1]

BIOLOGICAL ACTIVITY In vitro. Active against Gram-positive bacteria. Inhibits (μg/ml) Sarcina lutea, Micrococcus flavus, 0.1; Bacillus anthracis, B. megatherium, 1.0; B. subtilis, 1-3; M. pyogenes var. aureus, 2; Mycobacterium phlei, 75. The following were not sensitive to 100 μg/ml: Escherichia coli, Shigella dysenteriae, Salmonella paratyphi, Proteus vulgaris, Pseudomonas aeruginosa; also Penicillium chrysogenum, Aspergillus niger, Saccharomyces cerevisiae, Candida albicans.[1]

TOXICITY LD_{50} in mice, approximately 250 mg/kg, i.v. [1] .

308. TETAINE

SOURCE Bacillus pumilus [2] .

FORM AND COLOR Amorphous, colorless powder [1, 2] .

SOLUBILITY s. methanol, ethanol, ethylene glycol, water, water-saturated phenol[4] [1] ; i. acetone, chloroform, ether, petroleum ether, benzene, butanol, propanol.[3]

STABILITY Stable in water; unstable to drying.[1, 3]

OTHER REACTIONS Very hygroscopic [3] . Positive ninhydrin; negative COOH, NH_2 tests; dialyzable; not precipitated by protein precipitants.[1, 2]

BIOLOGICAL ACTIVITY In vitro. Inhibits a variety of Gram-positive and Gram-negative bacteria. Shigella dysenteriae especially sensitive; inhibited by concentration of 8 μg/ml. [1, 2] Micrococcus pyogenes var. aureus and species of Salmonella, Proteus, and Klebsiella are sensitive [3] .

TOXICITY Described as slightly toxic. In vitro. Non-hemolytic to erythrocytes.[3]

309. TETRACYCLINE

Trademarks for tetracycline are Achromycin (Lederle Laboratories Division, American Cyanamid Company),
Panmycin (The Upjohn Company), Polycycline (Bristol Laboratories, Inc.),
Steclin (E. R. Squibb and Sons, Division of Olin Mathieson Chemical Corp.), and Tetracyn (Chas. Pfizer & Co., Inc.).

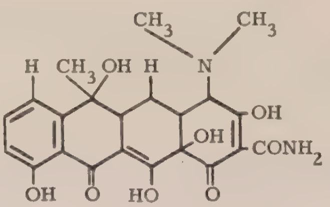
SOURCE Streptomyces spp [3] , and by catalytic reduction of chlortetracycline [1, 2] .

NATURE Amphoteric [4] .

MOLECULAR FORMULA AND WEIGHT $C_{22}H_{24}N_2O_8$; 227 (equiv. wt. found); 444 (calc.).[2, 4]

/1/ Also produces tertiomycin A, eurocidin, and azomycin. /2/ From benzene. /3/ 1% ethanol. /4/ Reference 2 reports s. water, i. organic solvents.

STRUCTURE



[2]

CRYSTAL FORM Base: orthorhombic[1] [3] .

MELTING POINT (°C) Anhydrous form: 170-173 (d.) [1, 2] ; 170-175 (d.) [4] . HCl: 214 [1, 2] .

OPTICAL ACTIVITY Base: $[\alpha]_D^{25} = -239°$[2] [2, 4] . HCl: $[\alpha]_D^{25} = -257.9°$[3] [1] .

UV ABSORPTION MAXIMA 220, 268, 355 mμ[4] [1] ; 268, 363 mμ[5] [2] ; 246, 372 mμ[6] [2] .

SOLUBILITY Trihydrate: sl. s. water[7]. HCl: s. water[8]. [6]

STABILITY Stable in solution of pH 7.0; 50% loss in 12 hours at pH 8.85; no loss in 0.1 N H_2SO_4 in 48 hours, but about 40% after 8 days at room temperature; 40% loss in 3 weeks in pH 4 buffer.[3, 5]

OTHER REACTIONS Produced by fermentation or when chlortetracycline is dehalogenated in presence of palladium; pKa 8.3, 10.2[9]; with Ehrlich in dilute aqueous HCl, oxytetracycline gives a bluish-green precipitate after 8 hours and a bluish-green supernatant, chlortetracylcine a canary yellow solution, tetracycline an orange-yellow solution (chlortetracycline does not inhibit development of color with oxytetracycline while tetracycline does). With H_2SO_4, oxytetracycline is cherry-red, chlortetracycline purple and later greenish black, tetracycline a stable violet color [1-3] . Like its chloro- and hydroxy- derivatives, tetracycline has a high affinity for divalent cations of heavy metals [80] .

QUANTITATIVE DETERMINATION Microbiological: Klebsiella pneumoniae[10], Bacillus subtilis, Escherichia coli, Sarcina lutea [3, 5, 7] . Colorimetric [78, 79] .

BIOLOGICAL ACTIVITY Antimicrobial spectrum similar to that of its analogues, chlortetracycline and oxytetracycline. In vitro. In general, most strains of the following Gram-positive and Gram-negative bacteria are inhibited by 0.05-5.0 μg/ml: B. anthracis, B. subtilis, Aerobacter aerogenes, Brucella bronchiseptica, Clostridium perfringens, Cl. tetani, Corynebacterium diphtheriae, C. xerose, Diplococcus pneumoniae, Erysipelothrix rhusiopathiae, E. coli, Hemophilus ducreyi, H. influenzae, K. pneumoniae, Listeria monocytogenes, Micrococcus pyogenes var. aureus, Mycobacterium tuberculosis, Myco. smegmatis, Myco. phlei, Myco. ranae, Neisseria catarrhalis, N. gonorrhoeae, N. meningitidis, Pasteurella multocida, Salmonella typhosa, S. paratyphi, S. schottmuelleri, S. gallinarum, Sarcina lutea, Shigella dysenteriae, Sh. sonnei, Streptococcus pyogenes, Str. viridans, Str. faecalis. Strains of Pseudomonas aeruginosa and Proteus spp vary widely; majority are resistant to 50 μg/ml or more. Yeasts and fungi not sensitive.[3, 7-15] Inhibits Entamoeba histolytica in concentrations of 62-250 μg/ml [16] . Concentrations of 2 mg/ml failed to inactivate the virus of herpes simplex [72] .

In vivo. Single or multiple s.c. or i.p. doses of 5-25 mg/kg gave good protection in mice infected with D. pneumoniae, Str. pyogenes, Str. mitis, M. pyogenes var. aureus, K. pneumoniae (type A), or Past. multocida; higher doses of 40-50 mg/kg required for 100% protection against Salmonella typhosa and K. pneumoniae (type B).[8, 17, 18] Some protection afforded in experimental tuberculosis in mice with s.c. doses of 100 mg/kg/da; the order of activity resembled that of oxytetracycline.[18] Daily s.c. doses of 75-125 mg/kg increased survival time in mice infected intracerebrally with Myco. tuberculosis var. hominis. Oral doses effective in mice infected i.v. with Myco. tuberculosis var. bovis.[73] The median protective dose against experimental tetanus infection in mice was 14.1 mg/kg, injected i.p. daily for 5 days [81] . Ten daily intramuscular injections of 10 mg/kg in rabbits cured experimental syphilitic orchitis [82] . Doses as low as 0.031 mg per egg were active against feline pneumonitis virus in chick embryos; the action appeared to be virustatic rather than virucidal [84] . Doses of 65 mg/kg/da, administered i.p., prolonged survival time in chicks infected with S. gallinarum; did not eradicate the carrier state.[18] Multiple i.p. amounts of 20 mg/kg suppressed B. anthracis and L. monocytogenes in mice; partial protection against Ery. rhusiopathiae with higher doses of 80 mg/kg.[19] The antibiotic failed to protect mice infected with a strain of M. pyogenes var. aureus which was resistant to chlortetracycline and oxytetracycline [17] . Prolonged survival time in mice with experimental toxoplasmosis, but was less effective, on a weight basis, than chlortetracycline [20, 21] . Daily i.p. doses of 10-20 mg/kg suppressed infections with Eaton's atypical pneumonia virus in cotton rats [22] . High i.p. doses of 100-150 mg/kg had an adverse effect on Candida albicans, enhancing the infection in mice [23, 24] . A number of new tetracycline derivatives were much more active against Trichomonas vaginalis in vitro and in vivo in mice than the parent antibiotic; none of these derivatives was active against Trypanosoma equiperdum infection.[83]

/1/ Refractive indices: $\alpha = 1.572 \pm 0.005$, $\beta = 1.646 \pm 0.005$, $\gamma = >1.750$. /2/ c, 1 methanol. /3/ c, 0.5 in 0.1 N HCl. /4/ 0.1 N HCl. /5/ 0.01 M methanolic HCl. /6/ 0.01 M methanolic NaOH. /7/ 0.36 mg/ml at 26.5°C. /8/ 132 mg/ml at 26.5°C. /9/ 50% aqueous dimethylformamide. /10/ ATCC 10,031, PCI 602.

CLINICAL This broad-spectrum antibiotic is effective in a wide variety of infections caused by susceptible organisms, including pneumonia, scarlet fever, otitis media, acute pharyngitis, sinusitis, osteomyelitis, laryngotracheobronchitis, meningitis, surgical infections, infections of the urinary tract and soft tissues. The uses and indications are similar to those described for the two analogues, chlortetracycline and oxytetracycline, although tetracycline is not yet as fully evaluated clinically. In general, it is not routinely used as an alternative agent for infections resistant to the analogues since cross resistance to these antibiotics is common although not absolute. Clinical studies have shown that tetracycline may be effective after therapy with its analogues has proved ineffective. The usual dosages are similar to those employed for the analogues. The suggested minimum daily oral dose is 1-2 g divided into 4 equal parts and for children proportionately less, e.g., 20-25 mg/kg/da in 4-5 divided doses.[5, 8, 9, 11, 25-34] Parenteral administration with intramuscular and intravenous preparations has been frequently used [29, 35, 36] . Excellent results have been reported in acute gonorrhea following single oral doses of 2 g or with the same amount in 8 divided doses administered over a 2-day period [37, 38] . Preliminary trials indicate favorable response in non-gonococcal urethritis following total oral doses of 6 g over a 6-day period [39] . A limited series of patients with acute or chronic brucellosis (probably caused by Br. melitensis) showed good clinical response when treated for 8-15 days with 12-50 mg/kg/da [40, 68] . Favorable preliminary results reported in lymphogranuloma venereum, donovanosis, and chancroid [41, 42] ; also in a small series of patients with psittacosis [43, 44] , exanthematic typhus [45] , and Rocky Mt. spotted fever [46] . Oral therapy was generally effective in patients with pustular dermatoses [47] , and for prophylaxis and treatment of surgical infections [48] . Preliminary trial suggests the drug is of value in acute amebiasis [49, 69] and in bartonellosis (Carrion's disease) [71] . Good results reported in 26 out of 27 cases of bacillary dysentery caused by Shigella sonnei [50] . Variable results noted in a series of 25 patients with typhoid fever treated with oral doses of 50-100 mg/kg/da over periods of 7-12 days [51] . Topical application in ointment base has been successful in the treatment of a variety of skin infections [52] , and in trachoma [70] . Appeared to benefit 36 out of 45 patients with infectious hepatitis treated with daily oral doses of 1-1.5 g for 1-12 days. The duration of illness was reduced from 5-8 weeks to 1-2 weeks.[74] . Tsutsugamushi disease successfully controlled with oral therapy [85] . Total oral doses of 10-14 g over periods of $5\frac{1}{2}$-8 days effective in treating human cases of anthrax infection [86] . Beneficial results in pertussis have been described [29] . The antibiotic was of no value in cases of active tuberculosis [5, 87] . Initial intravenous dosage of 7 mg/kg at 8-hour intervals, followed with oral therapy, has been successful in the treatment of H. influenzae meningtitis [88] . Good results have also been obtained in five cases of leptospiral meningitis [89] .

VETERINARY Value of tetracycline in veterinary practice is still under investigation. Preliminary reports indicate it is beneficial in bovine mastitis caused by Str. agalactiae.[53] Parenteral administration of 1-2 mg/lb of body weight was effective in cattle with shipping fever complex and pneumonia; also in infectious scours and pneumonia in swine.[54] In limited trials, cases of pneumonia-enteritis complex, mastitis and listeriosis in sheep responded favorably to therapy [55] . Oral medication with doses of 100-250 mg twice daily for 4-5 days was of value in feline distemper [54] ; pneumonia, bacillary enteritis and distemper complex in dogs responded to oral or parenteral medication [56] . Highly effective in the treatment of natural psittacosis infection in parakeets; a regimen of 0.4 mg administered i.m. twice daily for 14 days was employed.[57] Intramuscular doses of 2 mg/lb of value in canine and feline infection [75] . One or two doses of 2 mg/lb, i.m., effective in controlling shipping fever complex in cattle, sheep, and pigs [76] . Three i.m. doses protected sheep against experimentally induced anthrax infection [77] . In experimental anaplasmosis in splenectomized calves, single intravenous or intramuscular injection of 3 mg/lb body weight prevented increase in the number of Anaplasma marginale in red blood cells [90] . Daily oral doses of 50-160 mg/kg were highly effective in prophylaxis of an artificially induced enzootic (virus) pneumonia in pigs [91] . Daily intravenous medication with 2.5 mg/lb body weight in divided doses recommended for a variety of bacterial infections in dogs and cats, including peritonitis, endometritis, pneumonia, pharyngitis, otitis media, upper respiratory mixed infections, bronchitis, sinusitis, urinary tract infections, wound infections, and feline panleucopenia [92] . Multiple intramuscular doses controlled feline infectious anemia [93] . Topical therapy valuable in a wide variety of eye, ear and skin infections encountered in small animal practice [99] .

TOXICITY LD$_{50}$ in mice, 162-170 mg/kg, i.v.; 190-330 mg/kg, i.p.; 2130->3000 mg/kg, oral. LD$_{50}$ in rats, 129-220 mg/kg, i.v.; 320 mg/kg, i.p.; >3000 mg/kg, oral.[8, 58] Daily oral amounts of 100 mg/kg in mice and 100-400 mg/kg in rats for periods up to 30 days were well tolerated. In dogs, oral doses of 200-250 mg/kg/da for 12-14 weeks were non-toxic; no pathologic changes noted.[8, 58, 60] . Repeated i.v. doses were well tolerated with no effect on the liver or kidney function; no adverse cardiovascular or respiratory effects observed in anesthetized dogs.[58] Repeated injection of 50 mg/kg/da for 4 weeks, via the i.p. route, produced changes in abdominal viscera of weanling rats, but appeared less irritating than chlortetracycline [59] . Like its chloro- and hydroxy- derivatives, tetracycline is poorly tolerated in guinea pigs and hamsters. Three daily oral doses of 50 mg/kg in hamsters induced a frequently fatal diarrhea, with necrosis of the intestinal mucosa. These adverse effects were largely prevented by concurrent administration of 250 mg/kg/da of sulfaguanidine.[94] In vitro. In tissue cultures, tetracycline and oxytetracycline (but not chlortetracycline), in concentrations of 50 μg/ml, had a growth-stimulating action on embryonic cardiac tissue of the chick. All three antibiotics in concentrations of >100 μg/ml were toxic to fibroblasts. [96]

In man, the antibiotic appears to be well tolerated and although occasional nausea, vomiting, and diarrhea are noted following oral therapy, these side effects appear to be less frequently associated with tetracycline than with its analogues [5, 27-30] . Continued topical use of dermatological preparations containing 3% of the antibiotic is associated with a relatively low index of sensitization, in contrast to penicillin, streptomycin, and the sulfonamides [95] .

RESISTANCE In vitro. Resistance develops slowly in a gradual, stepwise manner. Resistant forms of M. pyogenes var. aureus and E. coli were developed by 10-12 consecutive transfers in the presence of increasing amounts of the antibiotic. Cross resistance shown by various microorganisms to all three tetracyclines, but not to other antibiotics.[3, 8, 61, 65]

ABSORPTION AND EXCRETION After single or repeated doses of tetracycline, concentrations in the blood appear at somewhat higher levels and are generally better sustained than has been noted for its analogues. It passes the blood-brain barrier more readily, producing higher cerebrospinal fluid concentrations than those usually obtained with either chlortetracycline or oxytetracycline. After oral ingestion, the antibiotic is excreted in the urine, bile and feces in a similar manner and retains its antimicrobial activity in the urine and gastrointestinal contents. In dogs, single oral doses of 6.2-12.5 mg/kg produced appreciable serum levels for at least 8 hours; after 10 mg/kg, i.v., therapeutic levels were maintained for approximately 24 hours; similar results in rabbits.[8, 58] . In chick embryo, application of antibiotic to chorioallantoic membrane is followed by rapid absorption, with peak concentrations in embryo after 2 days, and in the allanotic fluid on the third day. Injection into allantoic fluid resulted in 33% destruction of tetracycline within 48 hours; approximately 15% of active antibiotic remained after 8 days.[98]

In man, following repeated oral doses, peak blood concentrations of 2-8 μg/ml noted, with levels of approximately 320 μg/ml in the urine in 6-12 hours, and detectable concentrations in the spinal fluid, pleural fluid, saliva, abdominal fluid and cord serum [3, 61-63] . Repeated i.v. doses produced high blood concentrations and levels of 1.25-5.0 μg/ml in cerebrospinal fluid [64] . Intramuscular administration of 10 mg/kg every 12 hours gave serum concentrations approximating those generally obtained after oral medication with the usual dosages [35] . Concentrations in thyroid tissue following oral therapy with tetracycline were significantly higher than those obtained with comparable doses of chlor- or oxytetracycline [97] .

MODE OF ACTION Essentially bacteriostatic in action, but higher concentrations may be bactericidal [3, 8] . (See also chlortetracycline.)

ANIMAL NUTRITION Preliminary results with chicks and pigs indicate that, like certain other antibiotics, tetracycline may be of value as a feed supplement for stimulating growth in animals [3, 66, 67] .

310. THERMOPHILLIN

SOURCE Lenzites thermophila [1] .

NATURE Quinonoid properties [1] .

MOLECULAR FORMULA $C_{18}H_{18}O_9$ [1] .

CRYSTAL FORM AND COLOR Golden plates [1] .

SOLUBILITY sl. s. ethanol, ether, chloroform, water; i. most organic solvents.[1]

STABILITY Thermostable at neutral and acid pH; unstable in alkali [1] .

OTHER REACTIONS Sublimes at 245°C in air, 260°C in sealed tube; yellow aqueous solution, changing to red in alkali; I from KI; reduced to colorless with sodium hydrosulfite; bright red with concentrated H_2SO_4, becoming brown on heating and yellow upon addition of ethanol.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits M. pyogenes var. aureus in dilution of 1:10,000 [1] .

311. THERMOVIRIDIN

SOURCE Thermoactinomyces viridis, n. sp, resembling T. monospora [1] .

NATURE Acidic [1] .

UV ABSORPTION MAXIMA 268-272 mμ [1] .

STABILITY Stable for 21 hours at pH 2-8 at 37°C; at pH 10, 50% loss at 8 hours.[1]

OTHER REACTIONS Negative biuret, ninhydrin, xanthoproteic, Molisch, lead acetate; dialyzable; precipitated with $(NH_4)_2SO_4$.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209-P [1] .

BIOLOGICAL ACTIVITY In vitro. Preparations containing 64 units per mg inhibited (units/ml) Clostridium septicum at 0.03; Sarcina lutea, 0.25; Bacillus subtilis, 0.5; M. pyogenes var. aureus, including strains resistant to penicillin, 1-4; Cl. tetani, 2; Diplococcus pneumoniae, 4; Streptococcus pyogenes, 4-16; Str. viridans, Corynebacterium diphtheriae, 16; Proteus vulgaris, Escherichia coli, Shigella paradysenteriae, Salmonella typhimurium, 64. The following were not sensitive to 26 units/ml: Mycobacterium tuberculosis var. hominis, Myco. phlei; also Nocardia asteroides, Candida albicans, Blastomyces dermatitidis, Aspergillus fumigatus, Histoplasma capsulatum, Trichophyton mentagrophytes. No loss of in vitro activity in the presence of sheep blood.[1]

TOXICITY Mice tolerated i.p. doses of 32 mg of material containing a total of 800 units of antibiotic activity [1] .

312. THIOAURIN

(Antibiotic HA-9, Orosomycin)

SOURCE Streptomyces sp related to S. lipmanii [1, 2] .

MOLECULAR FORMULA AND WEIGHT $C_7H_6N_2O_2S_2$ [2] , or $C_{14}H_{12}O_4N_4S_4$ (proposed) [1] ; 226 (Rast); 214 (calc.) [2] ; 290-400 (Rast) [1] .

CRYSTAL FORM AND COLOR Yellow crystals.

MELTING POINT (°C) 179-181 [1] ; 175-180 [2] .

OPTICAL ACTIVITY $[\alpha]^{25}_{D} = 0$[1] [2] .

UV ABSORPTION MAXIMA 232, 370 mμ [1] .

SOLUBILITY Crude: s. methyl isobutyl ketone, ethyl acetate, n-butanol, chloroform, i. or sl. s. benzene, ether. Crystalline: s. methanol; sl. s. ethyl acetate; i. water, chloroform.[2]

OTHER REACTIONS Negative $FeCl_3$; zones greatly enhanced at pH 6; solubility not affected by pH.[2]

QUANTITATIVE DETERMINATION Microbiological: Sarcina lutea [2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Salmonella typhosa, 1.1; Micrococcus pyogenes var. aureus, Proteus vulgaris, 4.5; Bacillus subtilis, Aerobacter aerogenes, Klebsiella pneumoniae, S. schottmuelleri, Mycobacterium tuberculosis, 1.6-6.2; Escherichia coli, 9; Pseudomonas aeruginosa, 72-100. Yeasts and fungi (μg/ml): Saccharomyces cerevisiae, Aspergillus niger, 144; Chaetomium globosum, Myrothecium verrucaria, 100; Candida albicans, Cryptococcus neoformans, Blastomyces dermatitidis, Histoplasma capsulatum, Microsporum gypseum, Sporotrichum schenckii, Trichophyton mentagrophytes, 1000.[1, 2] In vitro activity appears to be enhanced by 25% serum [2] .

TOXICITY LD_{50} in mice, 15-16 mg/kg, i.v.; 20 mg/kg, s.c. Poor weight gains in mice receiving s.c. doses of 2 mg/kg/da for 7 days, with ulcerating nodules at site of injection.[1, 2] I.v. doses of 7.8 mg/kg lethal to dogs [2] .

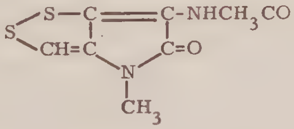
313. THIOLUTIN

SOURCE Certain strains of Streptomyces albus [6] .

NATURE Neutral [1, 16] .

MOLECULAR FORMULA $C_8H_8O_2N_2S_2$ [3] ; 228 (calc.) [16] .

STRUCTURE



[5, 16]

CRYSTAL FORM AND COLOR Brilliant yellow needles [1, 2, 16] .

MELTING POINT (°C) 270 (d.) [2, 16].

OPTICAL ACTIVITY Inactive [3, 16] .

UV ABSORPTION MAXIMA 245, 315, 365 mμ [2] ; 250, 311, 388 mμ [4, 16] .

SOLUBILITY s. most organic solvents; sl. s. water.[1, 2]

/1/ c, 0.75 glacial acetic acid.

STABILITY Acid stable, alkali labile [2] ; thermostable [16] .

OTHER REACTIONS Raney nickel treatment yields "desthiolutin" (MP 130-131°C); acid hydrolysis yielded an amine, $C_6H_6N_2OS_2$, identical to one so obtained from aureothricin.[3, 4] Sublimes without decomposition when heated in vacuo. Infrared: Carbonyl bands at 6.00 and 6.12 μ; NH stretching and bending absorption at 3.12 and 6.45 μ; strong C=C stretching absorption at 6.25 μ.[16]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus subtilis, 1; Proteus sp, Salmonella typhosa, 2.5; S. paratyphi, Escherichia coli, Mycobacterium spp, Micrococcus pyogenes var. aureus, 5; Aerobacter aerogenes, 7.5; Klebsiella pneumoniae, 10; Streptococcus faecalis, 15; Brucella bronchiseptica, Pseudomonas aeruginosa, 50-200. Fungi: Histoplasma capsulatum, 6.2; Microsporum audouini, Trichophyton rubrum, Epidermophyton floccosum, 12.5; Coccidioides immitis, C. brasiliensis, Blastomyces dermatitidis, 50. Candida albicans not sensitive. [2] Phytopathogenic fungi: Species of Pythium, Sphaeropsis, Sclerotinia inhibited by 10 ppm; Colletotrichum, Phomopsis, Rhizoctonia by 50-100 ppm.[7] Protozoa: Trichomonas vaginalis sensitive to concentration of 0.2 μg/ml; Entamoeba histolytica, Leishmania tropica, L. donovani, Trypanosoma cruzi, 4-7.8 μg/ml.[2, 8] Low levels (0.012 μg/ml) toxic to human spermatozoa [9] . Of several antibiotics tested, thiolutin was the most active against 4 species of Leptospira (L. mitis, L. canicola, L. icterohemorrhagiae, L. grippotyphosa), with nearly complete immobilization following exposure to concentrations of 60 μg/ml [17] .

In vivo. Slight suppressive effect in experimental infections with Trypanosoma cruzi, but toxic to mice at doses administered (0.25 mg/kg, i.p.) [10] . No activity against Plasmodium gallinaceum in chicks following 2 mg/kg/da, i.p. [11] .

TOXICITY LD_{50} in mice, 25 mg/kg, s.c.; 25 mg/kg, oral.[2]

PHYTOPATHOLOGY Sprays useful in control of fire blight of apple trees (caused by Erwinia amylovora) [12] , and late blight of potato [13] . Levels of 10-20 ppm effectively controlled tomato wilt caused by Bacterium lycopersici [14] . Use in concentrations up to 1% as dust markedly improved germination of oat grain infected with the fungus Helminthosporium sativum. Levels of 100 ppm non-toxic to leaves of young tomato plants, roots of maize, pea, tomato, sunflower, or to seeds of maize, pea or radish.[7]

MISCELLANEOUS Concentration of 1 μg/ml inhibited secondary yeast growths in unpasteurized beer. Combinations with polymyxin or penicillin very effective in protecting against microbiologic contaminants in finished beer. [15] Growth of wheat roots in distilled water (but not in tap water) was stimulated by addition of 0.32 ppm of thiolutin [18] . The antibiotic was a potent molluscacide; concentrations of 0.06-0.25 μg/ml were lethal to snails (Australorbis glabrata) in 12-24 hours [19] .

314. THIOMYCIN

SOURCE Streptomyces sp resembling S. phaeochromogenus var. chloromyceticus [1] .

CRYSTAL FORM AND COLOR Golden yellow needles[1] [1] .

MELTING POINT (°C) 176-178 (d.) [1] .

SOLUBILITY s. methanol, ethanol, butanol, amyl alcohol, acetone, ethyl acetate, chloroform, benzene; sl. s. water, ether, petroleum ether.[1]

STABILITY Stable at pH 2; unstable to alkali.[1]

OTHER REACTIONS Analysis: C, 49.61; H, 5.50; N, 8.88; S, 16.26. Negative ninhydrin, $FeCl_3$, Fehling; some resemblance to thioaurin.[1]

QUANTITATIVE DETERMINATION Microbiological: Proteus vulgaris (OX-19)[2] [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Bacillus anthracis, Salmonella enteritidis, Proteus vulgaris, 3.2; Micrococcus pyogenes var. aureus, B. subtilis, Escherichia coli, Shigella sonnei, Mycobacterium tuberculosis, 12.5; Pseudomonas aeruginosa, 100.[1]

TOXICITY Very toxic in mice; LD_{50}, 10 mg/kg, s.c. [1]

315. THIOSTREPTON

SOURCE Streptomyces sp [1] .

MOLECULAR WEIGHT 420 (equiv. wt.) [2] .

MELTING POINT (°C) 246-256 (d.) [2] .

/1/ Ethyl acetate. /2/ More active at pH 6 than at 6.8.

315. THIOSTREPTON (Concluded)

OPTICAL ACTIVITY $[\alpha]^{23}_{D} = -98.5^{\circ 1}, -61^{\circ 2}, -20^{\circ 3}$.[2]

UV ABSORPTION MAXIMA None; shoulders at 225, 250, 280 mμ.[2]

SOLUBILITY s. chloroform, dioxane, pyridine, glacial acetic acid, dimethylformamide; i. water, lower alcohols, non-polar organic solvents.[2]

STABILITY Stable 4 days in broth at 37°C; loses 80% of activity in 8 days.[1]

OTHER REACTIONS Analysis: C, 51.3; H, 5.4; N, 14.6; S, 7.4; methoxyl or thiomethyl, 0. Infrared: 3.05, 3.5, 5.7, 6.02, 6.2, 6.6, 7.25, 8.3, numerous from 9-14, and a broad band at 14.5 μ. Tests using dioxane as a solvent give higher values than centrifuged beers; dissolves in methanolic acid or base with inactivation; positive biuret; negative ninhydrin, Sakaguchi; probable amino acids are leucine (or isoleucine), valine, alanine, threonine, proline, lysine, glycine, aspartic acid, glutamic acid, cystine, tryptophan.[1, 2]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus 209-P [1].

BIOLOGICAL ACTIVITY In vitro. Primarily active against Gram-positive bacteria. Inhibits (μg/ml) Streptococcus pyogenes at 0.003; M. pyogenes var. aureus (including strains resistant to penicillin, streptomycin, chloramphenicol, carbomycin, erythromycin and the tetracycline antibiotics), 0.024-0.125; Bacillus subtilis, Clostridium septicum, 0.03; Str. faecalis, Lactobacillus acidophilus, 0.06; Neisseria gonorrheae, 0.3; Mycobacterium tuberculosis var. hominis (strain BCG), 3; Diplococcus pneumoniae (type 2), 4-8. The following Gram-negative bacteria were insensitive to 50 μg/ml: Escherichia coli, Aerobacter aerogenes, Pseudomonas aeruginosa, Proteus vulgaris, Klebsiella pneumoniae, Salmonella schottmuelleri, Shigella spp. No activity against fungi.[1]

In vivo. Active in mice infected with an M. pyogenes var. aureus strain resistant to penicillin and the tetracyclines when injected in doses of 25-50 μg per mouse, i.v. Two daily doses of 6-10 μg, i.v., or 50 μg, s.c., protected mice against Str. pyogenes.[3]

PHARMACOLOGY In mice, antibiotic apparently is not absorbed from the gastrointestinal tract following oral doses as high as 250 mg/kg [3].

RESISTANCE No cross resistance shown between thiostrepton and penicillin, streptomycin, erythromycin, carbomycin, tetracycline, neomycin, or gramicidin [1].

MODE OF ACTION Essentially bacteriostatic [1].

316. TOXIMYCIN

SOURCE Bacillus subtilis [2].

NATURE Polypeptide or protein [1].

SOLUBILITY s. water at pH 6-10, 80% ethanol, 50% acetone; less s. water at pH 5-6, absolute ethanol, glacial acetic acid; sl. s. dioxane, n-butanol, isopropanol; i. acetone, ether, chloroform, benzene, methyl, ethyl and amyl acetates, water below pH 5.[1]

STABILITY Thermostable in buffer at pH 6.8; thermolabile in water, especially at alkaline pH.[1]

OTHER REACTIONS Positive Millon, xanthoproteic, biuret, ninhydrin; negative Fehling; slowly dialyzable; not inactivated by pepsin or trypsin.[1]

QUANTITATIVE DETERMINATION Microbiological: Glomerella cingulata [1].

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Trichophyton mentagrophytes, 6.25; G. cingulata, 12.5-25; Gliocladium fimbriatum, Alternaria solani, Botrytis allii, Chalara quercina, Penicillium notatum, 25; Helminthosporium spp, Sclerotinia fructicola, 25-50; Saccharomyces cerevisiae, 50. Bacteria (μg/ml): Bacillus cereus, 25; Xanthomonas campestris, 25-50; Micrococcus pyogenes var. aureus, 50-100; Corynebacterium sp, 250.[1]

PHYTOTOXICITY Concentrations of 1.0 mg/ml non-toxic to a variety of plants [1].

PHYTOPATHOLOGY Good protection against Alternaria solani on tomato foliage at 45-300 μg/ml. Inhibited lesion development in leaves of cowpea plants infected with tobacco necrosis virus.[1]

317. TOYOCAMYCIN
(Toyokamycin)

SOURCE Streptomyces sp resembling S. albus [1].

/1/ c, 1 in glacial acetic acid. /2/ c, 1 in dioxane. /3/ c, 1 in pyridine.

NATURE Weakly basic [1].

CRYSTAL FORM AND COLOR Free base: colorless needles [1].

MELTING POINT (°C) 233-234 [1].

UV ABSORPTION MAXIMA 230, 277 mμ[1]; 235, 273 mμ[2]; 233, 280 mμ[3].[1]

SOLUBILITY s. methanol, ethanol, n-butanol, ethyl acetate, acetone; sl. s. water (1 mg/ml); i. benzene, chloroform, ether, petroleum ether. HCl: s. water [1].

STABILITY Relatively stable at pH 5; unstable at pH 2, 7, 9.[1]

OTHER REACTIONS Culture produces 2 other antibiotics; negative Sakaguchi, Fehling, $FeCl_3$, Molisch, Millon, Ehrlich. Analysis: C, 49.14; H, 4.34; N, 23.77; O, 22.75.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Candida albicans at 1.6; Saccharomyces cerevisiae, 6.2; Willia sp, 100. The following were not sensitive to 100 μg/ml: Aspergillus niger, Mucor pusilis, Absidia orchidis, C. krusei, Torula utilis, Trichophyton interdigitale.[2]

318. TRICHOMYCIN

SOURCE Streptomyces hachijoensis, n. sp [3].

FORM AND COLOR Yellow amorphous powder [1].

MELTING POINT (°C) 155 (d.) [1].

UV ABSORPTION MAXIMA 286, 346, 364, 384, 405 mμ [1].

SOLUBILITY s. water, aqueous acetone, aqueous methanol, aqueous ethanol at slightly alkaline pH; less s. butanol, ethanol, methanol, acetone; i. ether, petroleum ether, ethyl acetate, amyl alcohol.[1]

STABILITY Thermostable at pH 7-8.5; unstable at pH 2.[1]

OTHER REACTIONS No N, S, or halogens; color changes from yellow to brick red upon decomposition; blue color becoming violet upon addition of concentrated H_2SO_4 or HCl; negative $FeCl_3$, ninhydrin, biuret, Fehling, Benedict, Molisch, Tollens, quinone reactions [1]. Precipitated by acridine derivatives (rivanol, acriflavin), sulfonamides, basic antibiotics, enzymes, dyes, metallic salts; rivanol-trichomycin water-insoluble salt especially useful; can be separated into fractions A, B, C by alumina chromatography [9, 10].

QUANTITATIVE DETERMINATION Microbiological: Candida albicans [2].

BIOLOGICAL ACTIVITY In vitro. Inhibits spirochetes and protozoa (μg/ml): Treponema pallidum immobilized by concentration of 250 in 9 minutes; Trichomonas vaginalis, T. foetus immobilized by 0.6; Trypanosoma gambiense and Borrelia duttoni also sensitive. The yeast-like fungus, C. albicans, inhibited by 5 μg/ml.[1, 4, 19] Inhibited 56 strains of C. albicans at 0.05-0.4 units/ml [11]. Most strains of C. tropicalis, C. krusei, inhibited by 2.5-10 μg/ml. C. solani, Torulopsis spp, Saccharomyces carlsbergensis, Hansenula anomala, and Rhodotorula mucilaginosa not sensitive to high concentrations [17]. Active against Trypanosoma cruzi [12]. Concentrations of 0.1 μg/ml immobilized Leishmania donovani [13]. Reiter strain of Treponema pallidum inhibited by 0.047 μg/ml [18].

In vivo. No activity against Trypanosoma gambiense and Borrelia duttoni in mice [4]. I.p. doses of 10-50 μg gave high protection against Trichomonas vaginalis in mice [19]. S.c. doses of 1.8-28 mg/kg effective against s.c. infection with T. vaginalis in mice [14]. Four i.v. doses of 20 μg/da protected mice infected i.v. with C. albicans [15]. Daily oral doses of 10,000 Candida units for 10-20 days in rabbits were effective against experimental syphilitic orchitis [18].

CLINICAL A case of trichomonas vaginitis was successfully treated with daily oral doses of 18,000-27,000 units over a 3-week period [16]. Intravaginal use of tablets containing 50 mg in one or two daily doses for 4-7 days controlled vaginitis caused by T. vaginalis and C. albicans [5]. Topical administration of solutions containing 1-10 mg/ml effective in otitis media caused by Candida spp, and in infections of the external auditory canal caused by Candida or Absidia ramosa; no response in infections with Aspergillus sp.[6]

PHARMACOLOGY LD_{50} in mice, 160 mg/kg, s.c.; 4.2 mg/kg, i.p. Mice tolerated oral doses of 160 mg/kg, 830 mg/kg were lethal.[7] With preparations of 1900 units/mg, LD_{50} in mice: 34,000 units/kg, s.c.; 4200 units/kg, i.p., 4300 units/kg, i.v.[8] Small amounts were excreted in the urine of guinea pigs following s.c. or oral doses. [2] Concentration of >1.9 units/ml stimulated isolated frog heart. Respiration inhibited and cessation of cardiac

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/1/ Water. /2/ 0.1 N HCl. /3/ 0.1 N NaOH.

318. TRICHOMYCIN (Concluded)

contraction noted in rabbits after doses of 700-750 units/kg; doses of 475 units/kg had no effect on the blood count or liver function. Red blood cells lysed by concentration of 1.2 units/ml.[8]

In man, oral doses of 50 mg were tolerated [2] .

RESISTANCE C. albicans did not readily develop resistance in vitro; 8 to 23-fold resistance developed in 5 strains following 60 serial subcultures in antibiotic.[11] No in vitro resistance developed by T. vaginalis following contact of 30 generations with trichomycin [13] .

319. TRICHOTHECIN

SOURCE Trichothecium roseum (Link) [1] .

NATURE Neutral; ester [3] .

MOLECULAR FORMULA AND WEIGHT $C_{19}H_{24}O_5$; 312-332 (Rast); 332 (calc.).[3]

CRYSTAL FORM AND COLOR Slender, fibrous, colorless needles [1, 2] .

MELTING POINT (°C) 118 (corr.) [1, 2] .

OPTICAL ACTIVITY $[\alpha]^{18}_{D} = +44^{\circ}$[1] [1, 2] .

UV ABSORPTION MAXIMA 220, 334 mμ[2]; 230, 325 mμ[3].[2]

SOLUBILITY s. chloroform, acetone, benzene, ethanol; sl. s. petroleum ether, water.[1, 2]

STABILITY Thermostable; labile at pH 12.[1, 2]

OTHER REACTIONS Ester components are isocrotonic acid and trichothecolone (a ketonic alcohol); reduces cold permanganate, but not Br; forms 2, 4-dinitrophenylhydrazone; the acetyl, butyryl and crotonyl esters had the same order of activity as trichothecin.[2-4]

QUANTITATIVE DETERMINATION Microbiological: Inhibition of spore germination of Penicillium digitatum [1, 2] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): P. digitatum, 0.04; Neurospora crassa, 3.2; P. meleagrinus, P. oxalicum, P. spinulosum, Aspergillus niger, Chaetomium convolutum, Fusarium graminearum, Thamnidium elegans, Saccharomyces carlsbergensis, 16; A. fumigatus, Helminthosporium sacchari, P. citrinum, P. expansum, P. lilacinum, P. roqueforti, Mucor erectus, 80.[5] Animal pathogens (μg/ml): Histoplasma capsulatum, 3.2; Trichophyton mentagrophytes, T. rubrum, Microsporum canis, Cryptococcus neoformans, Candida albicans, 16; Blastomyces dermatitidis, Geotrichum cutaneum, T. interdigitale, T. sulfureum, Hormodendrum langeroni, 80; Coccidioides immitis, Sporotrichum tropicale, S. schenckii, S. beurmanni, >80. Nocardia asteroides and bacteria not sensitive to 80 μg/ml.[4]

TOXICITY Mice tolerated i.v. doses of 5 mg/kg; 12.5 mg/kg, toxic; 500 mg/kg, lethal. 250 mg/kg, s.c., lethal to rabbits. 1% solution topically applied irritated guinea pig and human skin; same concentration irritated rabbit eye and induced conjunctivitis.[4]

PHYTOPATHOLOGY Preinoculation spray with 500 ppm successfully prevented stem rust of wheat (caused by Puccinia graminis) under greenhouse conditions [7] . When sprayed on leaves 1 day after inoculation, trichothecin inhibited infection by tobacco mosaic, tobacco necrosis, and tomato bushy stunt viruses, but was ineffective when applied 2 days before. Direct antiviral activity questionable; has been suggested that antibiotic may have altered metabolism of host leaf cells so that virus particles could not multiply.[6]

320. TYROCIDINE

A component of tyrothricin, q.v.

SOURCE Bacillus brevis [1] .

NATURE Mixture of basic polypeptides [2-5] .

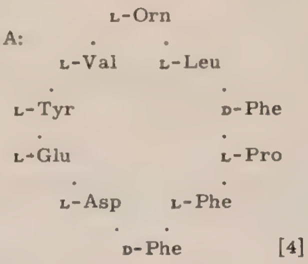
MOLECULAR FORMULA AND WEIGHT Mixture: $C_{127}H_{166}N_{26}O_{26}\cdot 2HCl$ (possible); 1000-3000 (found); 2546 (calc.). [3] Tyrocidine A[4]: $C_{66}H_{86}O_{13}N_{13}$ [4] ; 1270 (found).[6] B: $C_{68}H_{88}O_{13}N_{14}$; 1346 (calc.). Mono-DNP derivative: 1660 (found); 1512 (calc.). Di-DNP derivative: 1890 (found); 1678 (calc.).[16]

/1/ c, 1.0 chloroform. /2/ Chloroform or hexane. /3/ Ethanol. /4/ Tyrocidine A is one of polypeptides present in the mixture called "tyrothricin."

320. TYROCIDINE (Concluded)

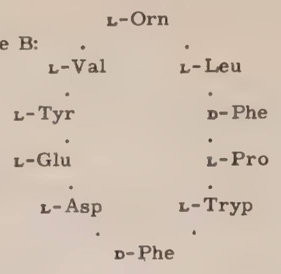
STRUCTURE

Tyrocidine A:



[4]

Tyrocidine B:



[17]

CRYSTAL FORM AND COLOR HCl: fine colorless needles or rods [1, 3, 5] .

MELTING POINT ($^{\circ}$C) Mixture: 237-239 (uncorr.) [2] ; 240 (corr., d.) [1, 3] . Tyrocidine A: 240-242 (d.) [5] .

OPTICAL ACTIVITY Mixture: $[\alpha]_D^{25} = -101^{\circ}$, -102°[1] [2, 3] . Tyrocidine A: $[\alpha]_D^{25} = -111^{\circ}$[2] [5] .

UV ABSORPTION MAXIMUM Tyrocidine A: 290 mμ [5] .

SOLUBILITY s. methanol, ethanol, acetic acid, pyridine (especially in presence of water); sl. s. water, dry acetone, dioxane; i. ether, hydrocarbons, chloroform, electrolytes.[1, 3, 5]

STABILITY Thermostable [3] .

OTHER REACTIONS Polypeptide component of tyrothricin; positive ninhydrin, p-dimethylaminobenzaldehyde, Millon; red color with diazobenzenesulfonic acid; precipitate with phosphotungstic acid; not digested by enzymes.[1, 3]

QUANTITATIVE DETERMINATION Microbiological: Streptococcus spp, Micrococcus conglomeratus [7-9] . Colorimetric[3] [10] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) M. lysodeikticus, Bacillus subtilis, 1; M. conglomeratus, 7; M. pyogenes var. aureus, 15-150; B. mycoides, Sarcina lutea, 3; Clostridium tetani, 2; Cl. perfringens, Actinomyces spp, 10; Diplococcus pneumoniae, 2-5; Str. pyogenes, 3-10; Neisseria gonorrhoeae, N. meningitidis, 40; Salmonella typhosa, 800; Escherichia coli, Aerobacter aerogenes, >300. Protozoa: Inhibits Trypanosoma cruzi at 100-200 μg/ml.[11]

In vivo. Little or no effect on M. pyogenes var. aureus or Cl. perfringens infections in mice [12] . No activity against T. cruzi in mice treated i.p. with doses of 5-10 mg/kg [13] .

TOXICITY LD_{50} in mice, 15 mg/kg, i.v.; 40 mg/kg, i.p. Oral doses of 1000 mg/kg tolerated.[14, 15] Depressed respiration in anesthetized animals [14] . In vitro. Rapid lysis of red blood cells by concentrations of 50-100 μg/ml. Low concentrations toxic to leukocytes and to frog embryos.[3]

321. TYROTHRICIN

SOURCE Bacillus brevis [1] .

COMPOSITION Consists mainly of approximately 20% gramicidin, and approximately 80% tyrocidine (q.v.), the latter usually present as the hydrochloride. Gramicidin (q.v.) is the more active component; tyrocidine, despite its high in vitro activity, loses much of this activity in vivo.[2]

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Diplococcus pneumoniae, 0.006-3.0; Streptococcus pyogenes, 0.2-10; Str. salivarius, 1-5; Str. faecalis, 1-20; Corynebacterium diphtheriae, 1; Micrococcus lysodeikticus, 0.1; M. pyogenes var. aureus, 1-200; M. conglomeratus, 5; Clostridium perfringens, 0.1-10; Cl. tetani, 2; Bacillus subtilis, Lactobacillus acidophilus, 3; Sarcina lutea, B. mycoides, 10; Neisseria meningitidis, 10->50; N. catarrhalis, 600; Escherichia coli, 800->800; Salmonella paratyphi, 800. In general, most Gram-negative bacteria are not sensitive. Fungi: Trichophyton schoenleinii, 50; T. mentagrophytes, Microsporum gypseum, 100; Candida albicans, 200.[2, 15] Spirochetes and protozoa (μg/ml): Borrelia vincentii, 5-20; Treponema pallidum, 1000; Trichomonas vaginalis, 50; Trypanosoma cruzi, 250.[3-6]

In vivo. Small i.p. doses protected mice infected with D. pneumoniae, Str. pyogenes (including strains resistant to sulfonamide drugs), and B. anthracis [7-10] . Prolonged survival time in mouse infections caused by M. pyogenes var. aureus and Cl. perfringens [8] . Experimental empyemata, induced with Str. pyogenes in rabbits, were sterilized after intrapleural administration of the antibiotic; similar infections with M. pyogenes var. aureus were more resistant to treatment.[11] Str. pyogenes eliminated from nasopharynx of monkeys and from knee joints of rabbits after local treatment [11, 12] . Tyrothricin protected chickens against infection with Plasmodium gallinaceum when given i.v. in doses of 2 mg/kg/da, but was inactive against P. lophurae in turkeys [13, 14] . Slight suppression of Trypanosoma cruzi in mice although the i.p. doses of 2.5-5.0 mg/kg were toxic [5] . No activity in experimental rabbit syphilis at maximum tolerated doses [6] . Local treatment failed to protect mice with Cl. perfringens

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/1/ c, 1 in 95% alcohol. /2/ c, 1.37 in 50% ethanol. /3/ For tyrothricin.

infection [16] .

CLINICAL The toxicity of tyrothricin is such as to preclude its parenteral use; it is ineffective orally and dangerous when administered i.v. The antibiotic may be employed with caution in body cavities provided there is no direct connection with the vascular system. It has been successfully used topically in superficial indolent ulcers, mastoiditis, empyema and wound infections when the predominating organisms are susceptible Gram-positive bacteria. Since it is effective only when in direct contact with microorganisms, it is of little or no value in deep-seated infections. Body fluids (e.g., saliva, urine, and serum) slightly depress its activity, and substances produced by Gram-negative bacteria markedly inhibit its action. The antibiotic is generally employed for topical application in solutions containing 0.5 mg/ml, or in ointment base. Indiscriminate use in irrigation of paranasal sinuses or other cavities close to subarachnoid spaces following surgery should be avoided in view of the danger of chemical meningitis. Local application of solution or ointment in infections caused by Streptococcus spp, D. pneumoniae, and M. pyogenes var. aureus has been successful, and the antibiotic is effective in tonsillitis, otitis, dermatoses, infected ulcers and burns, and in infections of the eye and conjunctiva.[17-22] Inhalation of 2 ml tyrothricin aerosol, 2-3 times daily, was beneficial in various forms of bronchitis; also in rhinopharyngitis and allergic rhinitis.[23, 27] Favorable results reported in patients with puerperal mastitis caused by M. pyogenes var. aureus when instilled immediately after surgical incision and administered topically thereafter [24] . Local use of the antibiotic in combination with phenylmercuric acetate gave generally favorable results in vaginitis caused by Trichomonas vaginalis [25, 26] . Solutions of 1 mg/ml in 70% alcohol effective in treatment of dermatomycoses caused by Microsporum canis, Trichophyton mentagrophytes, T. violaceum, but were ineffective in pityriasis versicolor caused by Malessezia furfur [28] . Dentifrices containing 0.2-0.5% antibiotic in powder base of value for controlling oral lactobacilli [29] . Although investigations in the United States indicate tyrothricin is very toxic when administered parenterally, a recent report from Hungary describes the successful i.v. administration of total doses of 25 mg which gave favorable results in D. pneumoniae pneumonia in 29 patients; also in cases of cholecystitis, and malaria. The response in malaria treated by the same route was striking; blood was cleared of plasmodia after the first injection.[30]

VETERINARY The antibiotic is of value in acute and chronic bovine mastitis; streptococci are eliminated from the udder, but M. pyogenes var. aureus is generally more resistant to treatment by intramammary instillation [2, 31-33] . Tyrothricin, in alcoholic or aqueous solution or in ointment base, has been effective in topical treatment of infected wounds, canine dermatoses and sarcoptic mange; also against ear mites of dogs, cats, and rabbits, and in scaly leg mange of birds.[33-35]

TOXICITY LD_{50} in mice and rats, 3.7 mg/kg, i.v.; 20-45 mg/kg, i.p. Oral doses as high as 1000 mg/kg were tolerated. Death apparently caused by respiratory failure since heart continued to beat for some time after cessation of respiration. Lethal doses in dogs caused anemia, and a fall in blood pressure and body temperature. Animals showed marked changes in lungs and abdominal viscera; histopathological examination revealed fatty degeneration of the liver and severe renal lesions. In rabbits or dogs, 0.3 mg/kg/da, i.v., produced ascites and liver damage. Consolidation in lungs noted when 5 mg were injected into the trachea of rabbits; 10 mg doses occasionally fatal.[2, 36-38] In vitro. Hemolysis of red blood cells and toxicity to leukocytes attributed mainly to tryocidine component [2] ; spermatozoa immobilized by concentration of 10 μg/ml [39] .

In man, parenteral use contraindicated because of toxicity. Olfactory disturbances occasionally observed following topical use as nose drops.[40] Chemical meningitis reported in 2 surgical patients following irrigation of sinus cavities in close proximity to subarachnoid spaces [41] . Topical use of dermatological preparations of tyrothricin is associated with a relatively low index of skin sensitization, in contrast to penicillin, streptomycin, and the sulfonamides [46] .

RESISTANCE Strains of M. pyogenes var. aureus developed resistance both in vitro and during therapy [42] .

MODE OF ACTION Bacteriostatic and bactericidal in low concentrations; produces lysis in certain bacteria. Resistance of Gram-negative bacteria may be caused by their phospholipid content. Inhibitory effect of serum on tyrothricin probably attributable to serum lipids.[2] In Cl. sporogenes, antibiotic causes slowing of processes of glucose phosphorylation because of rapid lytic action of tyrocidine on bacterial cells and liberation of phosphoric acid and adenosine triphosphate in supernatant fluid [43] . Gramicidin resembles cationic detergents in its effect upon surface tension and also in precipitation of proteins [2, 44] . (See also gramicidin.)

MISCELLANEOUS Useful in laboratory for selective isolation of anerobic Gram-negative bacteria from heavily contaminated sources when used in concentration of 2 μg/ml in culture media [45] .

322. UNGULINIC ACID

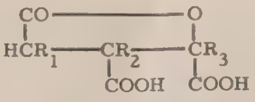
SOURCE Polyporus betulina [1] .

NATURE Potentially tribasic [1] .

MOLECULAR FORMULA $C_{22}H_{38}O_6$ [1] .

STRUCTURE

(Tentative)



I $R_1 = C_{16}H_{33}$, $R_2 = R_3 = H$
II $R_2 = C_{16}H_{33}$, $R_1 = R_3 = H$
III $R_3 = C_{16}H_{33}$, $R_1 = R_2 = H$

[1]

CRYSTAL FORM Microcrystalline needles [1] .

MELTING POINT (°C) 78-80 [1] .

OPTICAL ACTIVITY Inactive [1] .

SOLUBILITY s. organic solvents.

STABILITY Relatively unstable [1] .

OTHER REACTIONS The anhydride ($C_{22}H_{36}O_5$, MP 53-54°C, MW 358 cryo., 380.5 calc.) is more soluble in organic solvents and more stable; pink color when warmed with acetic anhydride at 100°C, giving green fluorescence upon addition of acetone; affords stearic, oxalic and acetic acids on KOH fusion.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [2] .

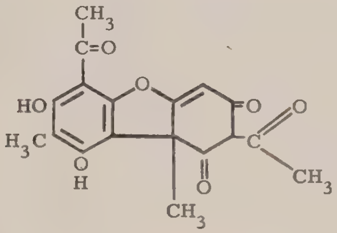
BIOLOGICAL ACTIVITY In vitro. M. pyogenes var. aureus was the only sensitive microorganism [2] .

323. USNIC ACID
(Usinic acid, Usnein)

SOURCE Various species of lichens [3, 7] ; also a fungal symbiont of a lichen [8] .

MOLECULAR FORMULA AND WEIGHT $C_{18}H_{16}O_7$ [4] ; 298-312 (neut. equiv.) [1] .

STRUCTURE



[2]

CRYSTAL FORM AND COLOR Yellow orthorhombic needles or tablets [5] .

MELTING POINT (°C) 193-204 [1] . (±) usnic acid, 195-196; (±) usnic acid diacetate, 205-207.[14]

OPTICAL ACTIVITY L-isomer: $[\alpha]_D^{20}$ = -445 to -478°[1]. D-isomer: $[\alpha]_D^{20}$ = +445 to +515°[2].[1, 4, 6]

UV ABSORPTION MAXIMA 226-230, 284 mμ [1] .

SOLUBILITY s. acetone, hot ethanol, hot propylene glycol, ether; sl. s. petroleum ether, cold ethanol, cold propylene glycol; i. water, HCl.[1, 4]

QUANTITATIVE DETERMINATION Microbiological: Bacillus subtilis, Sarcina lutea [3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis var. hominis, 1-50; Myco. tuberculosis var. bovis, 1.5-50; Myco. avium, 3-50; Myco. phlei, Myco. smegmatis, 5-50; Streptococcus pyogenes, 8-50; Diplococcus pneumoniae, 10-20; Micrococcus pyogenes var. aureus, 10-50; Escherichia coli, Klebsiella pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella typhimurium, 50.[1, 9] Neisseria meningitidis, Corynebacterium diphtheriae, Clostridium tetani, and Cl. perfringens are also sensitive [18] . Fungi: Trichophyton mentagrophytes, Torula utilis, Saccharomyces cerevisiae, Candida albicans are sensitive [10] .

In vivo. Daily s.c. doses of 10-20 mg showed slight activity in guinea pigs infected with Myco. tuberculosis (development of lesions delayed) [1] . According to another report, daily s.c. doses for 21 days in guinea pigs arrested development of tubercular lesions when treatment was begun on day of infection. When treatment was delayed, s.c. doses of 4-8 mg were less effective. Little or no activity when administered orally.[15] In still another

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/1/ c, 2.0-3.08 chloroform. /2/ c, 2.0-3.19 chloroform.

323. USNIC ACID (Concluded)

report, no activity against Myco. tuberculosis could be demonstrated in guinea pigs [16] . No activity in mice infected with D. pneumoniae [1] . No activity against mice infected with Lansing strain of poliomyelitis virus, or A-2 strain of Coxsackie virus [18] . No effect in chicks experimentally infected with Plasmodium gallinaceum [19] .

CLINICAL Preliminary trials in human pulmonary tuberculosis showed inconclusive results [11, 17] . When combined with streptomycin, antibiotic showed some promise in cutaneous tuberculosis [12] .

TOXICITY S.c. doses of 75 mg/kg lethal to mice. Guinea pigs tolerated 15-20 mg/da, s.c., for 3 weeks.[1] Rabbits tolerated daily oral doses of 460 mg/kg [18] . Maximum tolerated oral doses in 7-da-old chicks, 0.2 mg [19] .

MODE OF ACTION Actively bactericidal [9] . Inhibits oxidative phosphorylation and depresses orthophosphate which is normally associated with oxidation of various substrates by rat liver homogenates. In this respect the biological activity resembles that of atabrin, gramicidin, and chlortetracycline.[13]

324. USTILAGIC ACID

SOURCE Ustilago zeae [1] .

NATURE A mixture of closely related, partially acylated D-glucolipids [3] .

MOLECULAR FORMULA AND WEIGHT $C_{37}H_{62-66}O_{17}$; 777 ± 7 (neut. equiv.); 760 (found); 779-783 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless, needle-like crystals [1] .

MELTING POINT (°C) 144-147 [1] .

OPTICAL ACTIVITY $[\alpha]^{23}_{D} = +7^{\circ}$[1] [1] .

SOLUBILITY s. methanol, pyridine, 2, 3-butanediol, 1, 2-propanediol; sl. s. ethanol, butanol, acetone; i. water, glycerol, ethyl acetate, ether, benzene, petroleum ether.[1]

OTHER REACTIONS Saponification equivalent, 384; 42% glucose liberated on hydrolysis. C, 56.8; H, 8.2; terminal methyl as % acetyl, 11.9.[1] Alkaline hydrolysis yields amorphous gluco-ustilic acid, the removal of glucose residues from which yield ustilic acid; ustilic acid is a mixture of A and B, A being 15, 16-dihydroxyhexadecanoic acid, and B being 2, 15, 16-trihydroxyhexadecanoic acid.[3, 4]

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Ascochyta sp, Claviceps purpurea, Neurospora sitophila, 3.1-12.5; Chaetomium sp, Pleospora sp, Rhizoctonia solani, Aspergillus niger, 12.5-25.0; Helminthosporium sativum, Penicillium sp, Stachybotrys sp, Verticillium sp, 25-50; Alternaria tenuis, Armillaria mellea, Gliocladium roseum, Polyporus circinatus, >50; Cryptococcus neoformans, 10-15; Candida albicans, 15-20; Microsporum audouini, M. canis, Trichophyton mentagrophytes, T. rubrum, >50. Actinomycetes: Streptomyces griseus, Streptomyces sp, 3.1-12.5 μg/ml. Bacteria (μg/ml): Micrococcus pyogenes var. aureus, Xanthomonas campestris, X. translucens, 5-10; Bacillus subtilis, Corynebacterium flaccumfaciens, 10-20; Brucella bronchiseptica, 20-30; Mycobacterium butyricum, Escherichia coli, Pseudomonas aeruginosa, Aerobacter aerogenes, >50.[2]

TOXICITY Mice tolerate 1500 mg/kg, i.p., or 1% antibiotic in diet for 2 weeks. Rats tolerate 5% in diet for 3 weeks [2] .

325. VALINOMYCIN

SOURCE Streptomyces fulvissimus [1] .

MOLECULAR FORMULA AND WEIGHT $C_{36}H_{60}O_{12}N_4$; 713[2], 735[3] (found); 740.9 (calc.).[1]

CRYSTAL FORM AND COLOR Colorless, shining, rectangular platelets [1] .

MELTING POINT (°C) 190[4] [1] .

OPTICAL ACTIVITY $[\alpha]^{20}_{D} = +31.0^{\circ}$[5] [1] .

UV ABSORPTION MAXIMUM Approximately 282 mμ[6] [1] .

SOLUBILITY s. petroleum ether, ether, benzol, chloroform, glacial acetic acid, butyl acetate, acetone, concentrated H_2SO_4 (colorless); i. water, 2 N HCl, 2 N aqueous alkali.[1]

/1/ c, 1 pyridine. /2/ Beckmann in glacial acetic acid. /3/ Phenol. /4/ Berl-Block. /5/ c, 1.6 benzol.
/6/ n-Hexane, small broad peak.

325. VALINOMYCIN (Concluded)

OTHER REACTIONS 5 active H atoms; 4 C-methyl groups; no acetyl, methoxy, N-methyl or carboxy groups; all N accounted for as valine; negative ninhydrin.[1]

BIOLOGICAL ACTIVITY *In vitro*. Inhibits Mycobacterium tuberculosis in dilution of 1:900,000; Micrococcus pyogenes var. aureus, Bacillus subtilis, 1:20,000-1:30,000.[1]
In vivo. S.c. doses protected mice against Trypanosoma brucei infection [1] .

326. VANCOMYCIN

The trademark of Eli Lilly & Company for vancomycin is Vancocin.

SOURCE Streptomyces orientalis, n. sp [1, 4] .

NATURE Amphoteric [1] .

MOLECULAR WEIGHT 3200-3500 ± 200 (titr.) [1] .

FORM AND COLOR HCl: white solid [1] .

UV ABSORPTION MAXIMA HCl: 282 mμ[1] [1] .

SOLUBILITY HCl: s. water; less s. aqueous methanol; i. higher alcohols, acetone, ether. Solubility increased in neutral aqueous solution by low concentrations of urea [1] .

OTHER REACTIONS Precipitated from aqueous solution with phosphomolybdic acid, phosphotungstic acid, heavy metals; precipitated from acidic solutions with $(NH_4)_2SO_4$, NaCl.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [1] .

BIOLOGICAL ACTIVITY *In vitro.* Inhibits (μg/ml) Streptococcus pyogenes at 0.15-2.5; M. pyogenes var. aureus, 0.15->10 (strains resistant to penicillin, streptomycin, or erythromycin inhibited by 0.4-1.6); Bacillus megatherium, 0.2; Diplococcus pneumoniae, 0.29; Str. faecalis, 0.31-2.5; Str. viridans, 0.31->10; B. polymyxa, B. subtilis, Corynebacterium flaccumfaciens, C. sepedonicum, 0.4; Sarcina lutea, 0.4-1.6; B. licheniformis, C. diphtheriae, C. michiganense, Salmonella enteritidis, 0.8; Leptospira pomona, 1.0; Aerobacter aerogenes, 1.25->100; M. albus, 1.6; Neisseria catarrhalis, 2.5->10; B. brevis, B. cereus, Mycobacterium phlei, Myco. smegmatis, 3.1; Myco. avium, Flavobacterium sp, 100. Organisms insensitive to 100 μg/ml include Myco. tuberculosis, Pseudomonas aeruginosa, Escherichia coli, Shigella and Salmonella spp, Proteus vulgaris, Achromobacter fischeri; also yeasts and filamentous fungi.[1, 3]
In vivo. Parenteral doses protected mice against infections with M. pyogenes var. aureus, Str. pyogenes, and D. pneumoniae. Active against Borrelia novyi infection when administered orally or parenterally.[1]

CLINICAL Preliminary trials showed good clinical response in cases of pneumococcal pneumonia, streptococcal pharyngitis, and erysipelas, treated intravenously with 50-100 mg doses every 6-8 hours [2] .

TOXICITY LD_{50} in mice, between 400 and 500 mg/kg, i.v. Daily oral doses of 1000 mg/kg for one week, and 100 mg/kg, s.c., for 14 days, were tolerated in mice. Little or no tissue irritation following intramuscular injection in dogs and rabbits.[1] In man, intravenous doses of 50-100 mg every 6-8 hours for periods up to 7 days were well tolerated [2] .

ABSORPTION AND EXCRETION In man, intravenous doses of 50-100 mg gave serum levels of 0.5-2.0 μg/ml in 2-6 hours, with high concentrations in the urine at 24 hours [2] .

RESISTANCE Strains of M. pyogenes var. aureus developed resistance very slowly. Only an 8-fold increase in resistance developed after 25 transfers in the antibiotic.[3]

MODE OF ACTION Rapidly bactericidal to M. pyogenes var. aureus and Str. pyogenes in low concentrations (0.67-2.0 μg/ml). Like many other antibiotics, vancomycin is active only against multiplying bacteria. No lethal effect on either resting cells or respiring cells; no inhibition of oxidation of glucose by washed cells of M. pyogenes var. aureus.

327. VINACETIN

SOURCE Streptomyces sp [1] .

STRUCTURE Probably quinoid [1] .

CRYSTAL FORM AND COLOR Yellow platelets [1] .

/1/ In water.

327. VINACETIN (Concluded)

MELTING POINT (°C) 157-158 [1] .

SOLUBILITY s. ethyl acetate, butyl acetate, methanol, acetone; sl. s. water, trichloroethylene; i. ether, petroleum ether.[1]

STABILITY Most stable at pH 5; very unstable at alkaline pH.[1]

OTHER REACTIONS Violet color at alkaline pH; activity greatest at pH 5; almost inactive at alkaline pH; negative ninhydrin, Sakaguchi, Millon; positive Molisch (violet), $FeCl_3$ (brown), Liebermann, Fehling, Ag mirror; decolorized by H_2O_2 in Na_2CO_3 medium.[1]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus citreus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) M. citreus, 0.1-0.8; Corynebacterium diphtheriae, 0.8; Mycobacterium tuberculosis var. hominis, 5; Streptococcus pyogenes, 6; Str. viridans, 25; M. pyogenes var. aureus, 25-200; Myco. phlei, Myco. avium, 32; Proteus vulgaris, Neisseria meningitidis, Klebsiella pneumoniae, Escherichia coli, Shigella sonnei, 100-500.[1]

TOXICITY Mice tolerated 330 mg/kg, i.v. or i.p.; 660 mg/kg lethal by either route.[1]

328. VIOLACEIN

SOURCE Chromobacterium violaceum [1] .

NATURE Violet pigment [1] .

MOLECULAR FORMULA $C_{42}H_{35}O_6N_5$ [1] , or $C_{42}H_{28}O_7N_6$ [5].

CRYSTAL FORM AND COLOR Violet-black microcrystals; thick needles; elongated, rectangular crystals.[3]

MELTING POINT (°C) >350 (d.) [1] .

SOLUBILITY sl. s. ethanol, dioxane [2] .

OTHER REACTIONS Deep violet in ethanolic, purple-red in dioxane solution; acetate forms red-brown needles, MP >300°C (d.); forms stable addition compounds with aniline, chloroaniline, pyridine, chloropyridine; contains a β-hydroxypyrrylmethene.[2, 5, 6]

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus [4] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Bacillus subtilis, Neisseria meningitidis in dilution of 1:200,000; Streptococcus pyogenes, Str. viridans, 1:100,000; M. pyogenes var. aureus, B. anthracis, B. megatherium, B. mesentericus, 1:50,000; Diplococcus pneumoniae; Cornyebacterium diphtheriae, 1:20,000-1:30,000. Little or no inhibition, <1:3000: Escherichia coli, Proteus vulgaris, Hemophilus pertussis, Neisseria catarrhalis, Salmonella typhosa. Fungi: Saccharomyces cerevisiae sensitive to 1:200,000; Blastomyces dermatitidis, 1:100,000; Trichophyton rubrum, 1:10,000.[2] . Protozoa: Inhibits flagellates, ciliates, and soil amebas [7] .

In vivo. Very slight protection against Diplococcus pneumoniae in mice [4] .

TOXICITY Mice tolerated 100 mg/kg, i.p.[4]

329. VIOLACETIN

SOURCE Streptomyces sp resembling S. purpeochromogenus [1] .

NATURE Basic [1].

CRYSTAL FORM AND COLOR Light yellow, fine needles[1] [1] .

MELTING POINT (°C) HCl: >210 [1] .

UV ABSORPTION MAXIMUM 293 mμ[2] [1] .

SOLUBILITY HCl. s. water, methanol, ethanol; i. or sl. s. butanol, ether, petroleum ether, benzene, ethyl acetate, chloroform, acetone, dioxane.[1]

STABILITY Thermostable in aqueous acid, not in alkali [1] .

/1/ 500-950 μg/mg. /2/ Water.

329. VIOLACETIN (Concluded)

OTHER REACTIONS Analysis of HCl: H, 6.74; C, 38.26; N, 24.71; Cl, 9.33. Precipitated from aqueous solution by picric, Reinecke and phosphotungstic acids; negative $FeCl_3$, Fehling, biuret, Sakaguchi, glucosamine, xanthoproteic, Millon, maltol; positive diazo, ninhydrin.[1]

QUANTITATIVE DETERMINATION Microbiological: Escherichia coli, Bacillus subtilis PCI 219 [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Micrococcus citreus, M. flavus, E. coli, Salmonella typhosa, Brucella abortus, 0.3-0.6; M. pyogenes var. aureus, M. albus, Bacillus subtilis, Corynebacterium diphtheriae, S. schottmuelleri, S. hirschfeldii, S. enteritidis, Shigella dysenteriae, 1.26; Sh. paradysenteriae, 1.25-2.5; Diplococcus pneumoniae, 1.26-10; M. freudenrichii, Streptococcus faecalis, B. mesentericus, Salmonella paratyphi, S. typhimurium, Neisseria meningitidis, Hemophilus influenzae, 2.5; Serratia marcescens, Aerobacter aerogenes, Klebsiella pneumoniae, Mycobacterium tuberculosis var. hominis, 5; Clostridium botulinum, Cl. butyricum, Cl. sporogenes, 12-24; Proteus vulgaris, 20; Pseudomonas aeruginosa, 40. Fungi: Cryptococcus pararoseus, Torula rubra, Candida krusei, 50; C. albicans, 50-75; Aspergillus niger, 75; Trichophyton interdigitale, Saccharomyces saké, Willia anomala, 100.[1]

In vivo. Doses of 22-37.5 mg/kg, i.v. or i.p., gave good protection in mice infected with D. pneumoniae and Salmonella enteritidis. Single oral doses of 150 mg/kg afforded little or no protection. Three daily i.p. doses of 45 mg/kg protected mice against infection with ornithosis virus.[1]

PHARMACOLOGY Doses of 45 mg/kg, i.p.; 75 mg/kg, s.c.; 37.5 mg/kg, i.v.; and 375 mg/kg orally well tolerated. Following i.m. administration in rabbits, maximum plasma levels were produced in 20-60 minutes with rapid excretion thereafter.[1]

330. VIOMYCIN
(Vinactin A)

Trademarks for viomycin are Vinactane (Ciba Pharmaceutical Products, Inc.), and Viocin (Chas. Pfizer & Co., Inc.).

SOURCE Streptomyces floridae, n. sp, and other Streptomyces spp [2, 3, 5] .

NATURE Strongly basic polypeptide [1] .

MOLECULAR FORMULA $C_{17-18}H_{31-35}O_8N_9$ [1, 25] .

MELTING POINT (°C) Hydrated sulfate: 280 (d.) [2] . Anhydrous sulfate: 252 (d.) [3] .

OPTICAL ACTIVITY Sulfate: $[\alpha]_D = -32°$[1] [2] , $-39.8°$[2] [3] .

UV ABSORPTION MAXIMA 268 mμ[3]; 268.5 mμ[4]; 282.5 mμ[5]. [3]

SOLUBILITY Sulfate and HCl: s. water; i. most organic solvents.[2, 3]

STABILITY Very stable in acid; less stable in alkaline solution.[3]

OTHER REACTIONS Positive Sakaguchi, biuret, Fehling, ninhydrin; negative maltol, Molisch, Benedict; contains L-serine, α,β-diaminopropionic acid, a basic amino acid isomeric with lysine, and a guanidino compound; forms neutral salts. Infrared: 3.06, 3.40, 5.97, 6.06, 6.16, 6.43, 6.51, 6.60, 6.65, 6.71 (s), 6.87, 7.30, 7.49, 7.61 (s), 8.15, 8.65 (s), 9.23, 13.85 μ[6]. [1-3]

QUANTITATIVE DETERMINATION Microbiological: Klebsiella pneumoniae; mycobacteria.[2] Colorimetric [4] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Mycobacterium tuberculosis (including strains resistant to streptomycin and neomycin), 0.78-12.5; K. pneumoniae, 1-20; Corynebacterium diphtheriae, 1-25; Neisseria catarrhalis, N. meningitidis, 2.5-25; Escherichia coli, 2.5-100; Salmonella typhosa, 2.5->636; Myco. phlei, Myco. ranae, Myco. smegmatis, 10; S. schottmuelleri, Shigella paradysenteriae, 10-100; Hemophilus influenzae, 12; Bacillus subtilis, 20-25; Micrococcus pyogenes var. aureus, 25->100; Aerobacter aerogenes 25-40; Brucella abortus, Br. suis, H. pertussis, 50; Br. bronchiseptica, Salmonella paratyphi, 80; Streptococcus pyogenes, 80->100; Str. viridans, Pasteurella sp, Proteus sp, Pseudomonas aeruginosa, Vibrio comma, >100. Acintomyces bovis, Nocardia asteroides inhibited by 25 μg/ml.[2, 3, 6-8] Inhibited 8 strains of Shigella paradysenteriae at 0.3-10 μg/ml[24] . Inhibition (μg/ml) of B. anthracis by 1.56-25; Serratia marcescens and B. subtilis, 50-100; Erysipelothrix rhusiopathiae, >100.[26] Fungi not sensitive to 250 μg/ml: Aspergillus fumigatus, Blastomyces dermatitidis, Candida albicans, Histoplasma capsulatum, Cryptococcus neoformans, Sporotrichum schenckii, Trichophyton mentagrophytes [6] . Protozoa: Entamoeba histolytica, Trichomonas foetus, Trypanosoma cruzi not inhibited by 2000 μg/ml [6, 11] . Bacteriostatic for intracellular Myco. tuberculosis within rabbit macrophages in vitro at concentrations of 100 μg/ml; under same test conditions streptomycin, neomycin, and oxytetracycline were 4-10 times more active on a weight basis.[12]

In vivo. In mice infected with Myco. tuberculosis by the i.v. or intracerebral route, daily s.c. doses of 25-175 mg/kg gave good protection [2, 7, 8, 25] . In guinea pigs, 20-80 mg/kg/da, administered i.m., suppressed experimental tuberculosis; on a weight basis, the antibiotic was approximately 1/4 as active as streptomycin. Infections induced with either streptomycin-sensitive or streptomycin-resistant strains of Myco. tuberculosis

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/1/ c, 1 water. /2/ c, 1 water at pH 6.0; rotation varies with pH. /3/ 0.1 N HCl. /4/ pH 7. /5/ 0.1 N NaOH. /6/ In Nujol mull, s=shoulder on a stronger band.

were equally responsive to viomycin treatment.[9, 13] Marked therapeutic effect in guinea pig tuberculosis when treatment was delayed until the disease had progressed extensively [10] . Multiple s.c. or i.p. doses of approximately 12-40 mg/kg protected mice against infections with K. pneumoniae, Salmonella typhosa, Proteus vulgaris and Past. multocida; higher oral dosages also effective.[7, 14] In chicks, i.p. doses of 18 mg/kg had suppressive effect on S. gallinarum [14] . Higher doses of 80 mg/kg, i.p., were required to protect mice against B. anthracis; little or no activity in infections with Str. pyogenes, Diplococcus pneumoniae, M. pyogenes var. aureus, Listeria monocytogenes, Ery. rhusiopathiae or Ps. aeruginosa.[7, 14] The antibiotic showed activity in infections with mouse leprosy bacilli (Myco. lepraemurium) [15] . In embryonated eggs, viomycin suppressed Rickettsia typhi [5] , and was without effect against a variety of small viruses in mice or chick embryos [6] . No activity against Trypanosoma cruzi infection in mice treated with i.p. doses of 500 mg/kg [11] .

CLINICAL Viomycin is an effective antibiotic for the treatment of tuberculosis, but its usefulness is limited inasmuch as its activity is less impressive than that of streptomycin or isoniazid and because of its toxic potentialities. Earlier reports of clinical studies described toxic effects from disturbances of electrolyte balance and neurotoxic action on the eighth cranial nerve.[16] These hazards have been substantially reduced by the introduction of intermittent therapy with lower doses, e.g., regimens of 2 g administered i.m. twice weekly, preferably in combination with another tuberculostatic drug. The companion drug generally selected is isoniazid or para-aminosalicylic acid (PAS), but not streptomycin since streptomycin and viomycin have such similar neurotoxic potentialities that an additive toxic effect might be expected. Favorable responses in pulmonary and extrapulmonary tuberculosis have been reported after the use of such regimens, but the therapeutic efficiency of viomycin remains to be evaluated.[17-21]

PHARMACOLOGY LD_{50} in mice, 165-240 mg/kg, i.v.; 1381 mg/kg, s.c. LD_0 in mice, 120-176 mg/kg, i.v.; oral doses of 7500 mg/kg well tolerated. Doses of 120-210 mg/kg, s.c., once or twice daily for 5 days were tolerated.[2, 7, 22] Daily i.m. doses of 150 mg/kg non-toxic in guinea pigs [9] . In rats or dogs, 100 mg/kg/da, administered s.c. over periods of 5-6 weeks, appeared to be well tolerated with no significant effect on the blood count or liver and kidney function. Cats injected i.m. with 50-100 mg/kg/da for 25-40 days, developed disturbances in posture and gait. In anesthetized cats or dogs, 100 mg/kg, i.v., did not affect blood pressure or respiration. Repeated injection of 10% solution by several routes caused no signs of irritation in animals. Solutions containing 0.5 mg/ml had no effect on contractility or rhythmicity of isolated intestines or uteri.[22]

In man, renal and neural toxicity were observed in patients with advanced pulmonary tuberculosis, treated with daily i.m. doses of 30-75 mg/kg over periods of 14-182 days. Toxicity evidenced by renal irritation, slight elevation of blood urea N, abnormalities of serum electrolytes, vestibular and auditory disturbances, eosinophilia, and skin eruptions.[16, 23] Later reports indicate reduced incidence of these side effects by employing intermittent therapy and lower doses of 2.0 g every third day, especially in combination with PAS or isoniazid [17-19] . Preliminary tests in animals indicate the antibiotic is readily absorbed following parenteral or oral administration [7] . Preliminary results in experimental animals indicate a detoxication of the antibiotic by pantothenic acid; the pantothenate of viomycin was less toxic than the sulfate.[27] In vitro. Low toxicity in tissue cultures; complete inhibition of chick embryo heart explants required concentrations as high as 30 mg/ml or more [28] .

RESISTANCE Myco. tuberculosis may develop resistance in vitro and in patients during therapy. Resembles streptomycin in the pattern in which resistance develops although this resistance appears somewhat more slowly than with streptomycin. Strains of Myco. tuberculosis resistant to streptomycin or neomycin do not show cross resistance to viomycin.[6, 7, 9, 23]

331. VIRIDICATIN

SOURCE Penicillium viridicatum [1] ; P. cyclopium (Westling) [2] .

MOLECULAR FORMULA $C_{15}H_{11}O_2N$ [1] .

CRYSTAL FORM AND COLOR Colorless crystals; lustrous needles[1]; prisms[2].[1]

MELTING POINT (°C) 269 [1] .

OPTICAL ACTIVITY No rotation [1] .

SOLUBILITY s. boiling concentrated HCl; sl. s. cold organic solvents, dilute mineral acids.[1]

OTHER REACTIONS Infrared bands include 3.0, 6.08, 6.16, 6.34, 6.40, 6.68 μ; carbonyl derivative could not be prepared; monobenzoate formed when reacted with benzoyl chloride in pyridine; Na salt formed when treated with dilute or concentrated aqueous NaOH; Na salt deposits crystals of viridicatin on exposure to air; Na salt reacts with p-phenylphenacyl bromide and gives deep red color when reacted with diazotized sulfanilic acid; intense permanent green color with neutral aqueous $FeCl_3$.[1]

BIOLOGICAL ACTIVITY In vitro. Inhibits Mycobacterium tuberculosis in dilution of 1:15,000. No activity against other bacteria tested (Escherichia coli, Bacillus subtilis, Micrococcus pyogenes var. aureus) or protozoa (Entamoeba histolytica).[1]

/1/ From ethanol. /2/ From acetone, glacial acetic acid, ethylene glycol, monomethyl ether.

332. VIRIDINS

SOURCE Trichoderma viride [1] .

MOLECULAR FORMULA AND WEIGHT $C_{19}H_{16}O_6$ [3] ; 331 (found); 340 (calc.).[2, 3]

CRYSTAL FORM AND COLOR Colorless, rod-like prisms [1, 2] .
α-Viridin: fine colorless needles [3] .
β-Viridin: fine needles [3] .

MELTING POINT (°C) 217-223 (d.) [1, 2] .
α-Viridin: 208-217 (d.) [3] .
β-Viridin: 140 (d.) [3] .

OPTICAL ACTIVITY $[\alpha]_D^{19} = -222^{\circ}$[1] [1, 2] .
α-Viridin: $[\alpha]_D^{20} = -213.4^{\circ}$[2] [3] .
β-Viridin: $[\alpha]_D^{20} = -50.7^{\circ}$[2] [3] .

UV ABSORPTION MAXIMA α-Viridin: 241.3, 304.5 mμ[3].
β-Viridin: 241.5, 304 mμ[3].

SOLUBILITY s. chloroform, bromoform; sl. s. carbon disulfide, carbon tetrachloride; i. ether, camphor.[2]

STABILITY Stable in acid; very unstable in alkaline solution.[1]

OTHER REACTIONS α and β-viridin are isomeric; negative $FeCl_3$, Schiff, 1, 4-dihydroxynaphthalene, iodoform; does not decolorize Br in cold; deep red-violet with phloroglucinol and HCl; reacts with hydrazine, phenylhydrazine, 2, 4-dinitrophenylhydrazine; reduces Fehling, Tollens; red color with concentrated H_2SO_4, cold caustic soda.[1-3]

QUANTITATIVE DETERMINATION Microbiological: Inhibition of spore germination of Botrytis allii [3] .

BIOLOGICAL ACTIVITY In vitro. Inhibits fungi (μg/ml): Colletotrichum lini, Fusarium caeruleum, 0.003; B. allii, 0.006; Trichothecium roseum, 0.05; Fusarium culmorum, Cladosporium herbarum, Penicillium notatum, Stemphylium sp, 0.2; Cephalosporium sp, 0.8; Aspergillus niger, 3.1[4]; P. expansum, Stachybotrys atra, 6.25; Trichoderma viride, 50->50.[1, 4] Also inhibits (μg/ml) Candida albicans, Saccharomyces cerevisiae, Torula utilis, and Trichophyton interdigitale at 6.2; Botrytis sp, Mucor pusilis, 12.5; C. krusei, Willia sp, 25; Absidia orchidis, 50.[7] Ascochyta pisi sensitive to low concentrations. These levels were fungistatic; concentrations approximately 1000 times greater were required for fungicidal effect. No activity against bacteria.[1, 4] Protozoa: Inhibits Trypanosoma cruzi in dilutions of 1:800-1:1600 [5] .

In vivo. Slight suppressive effect on T. cruzi infection in mice treated with 0.5-5.0 mg/kg, i.p. [5] .

TOXICITY I.p. doses of 5 mg/kg toxic to mice [5] . Dilution of 1:10,000 lethal to Allium cepa in tissue cultures [6] .

333. VISCOSIN

SOURCE Pseudomonas viscosa [1] .

NATURE Acidic polypeptide [1-3] .

MOLECULAR WEIGHT 700-900 (Rast); 1100 (titr.).[3]

MELTING POINT (°C) 269 (d.) [3] .

OPTICAL ACTIVITY $[\alpha]_D^{20} = -162.2^{\circ}$ [3] .

SOLUBILITY s. ethanol, methanol, ether, acetone, alkaline phosphate buffer; i. distilled water.[1, 2]

STABILITY Thermostable [1, 2] .

OTHER REACTIONS A monocarboxylic acid with pK' of 6.10; acid hydrolysis yields a fatty acid mixture and glycine, alanine, valine, leucine, threonine; 2 fatty acids: volatile 2-decenoic acid ($C_{10}H_{18}O_2$) and non-volatile (-)-3-hydroxycapric acid ($C_{10}H_{20}O_3$).[3]

QUANTITATIVE DETERMINATION Microbiological: Mycobacterium 607 [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Myco. tuberculosis (including strains resistant to streptomycin and neomycin) in concentration of 10-20. No activity against other Gram-positive or Gram-negative bacteria.[2]

/1/ c, 1 chloroform. /2/ Chloroform. /3/ Alcohol. /4/ In another report, A. niger inhibited by 12.5 μg [7] .

333. VISCOSIN (Concluded)

In vivo. Slightly suppressed Myco. tuberculosis infection in guinea pigs. Slight activity in mice infected with influenza A (PR-8) virus following s.c. doses of 250 mg/kg/da for 3 days. In chick embryos, marked inhibition of infectious bronchitis virus of fowls, slight suppression of influenza and Newcastle disease viruses, but no activity against viruses of vaccinia or feline pneumonitis.[1]

TOXICITY Mice tolerated 50 mg/kg, i.p.; >250 mg/kg, s.c. Doses of 50 mg/kg or more produced necrosis at site of injection. [1]

334. WHITMORIN

SOURCE Pfeifferella whitmori [1] .

SOLUBILITY sl. s. chloroform; i. ether, benzene, nitrobenzene, xylene.[1]

STABILITY Stable in cold; unstable at 37°C (55% loss in 3 days); thermolabile.[1]

QUANTITATIVE DETERMINATION Microbiological: Corynebacterium diphtheriae mitis [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits Corynebacterium spp, Bacillus subtilis, Streptococcus pyogenes, Micrococcus pyogenes var. aureus, Diplococcus pneumoniae, Mycobacterium tuberculosis var. hominis, Neisseria meningitidis, N. gonorrhoeae. Very slight activity against enteric bacteria.[1]

In vivo. Very slight activity in guinea pigs infected with C. diphtheriae [1] .

335. XANTHELLIN

SOURCE Bacillus subtilis [1] .

NATURE Acidic [1] .

FORM AND COLOR Sodium salt: pale yellow, non-hygroscopic, amorphous solid [1] .

SOLUBILITY Sodium salt: s. water, methanol, ethanol, butanol, acetone; i. ether, chloroform, benzene, petroleum ether. Free acid: s. organic solvents; i. water.[1]

STABILITY Thermolabile; unstable at room temperature except at neutrality.[1]

OTHER REACTIONS Dialyzable; precipitates on acidification of aqueous solution.[1]

QUANTITATIVE DETERMINATION Microbiological: Bacillus cereus [1] .

BIOLOGICAL ACTIVITY In vitro. Inhibits (μg/ml) Sarcina lutea, 10; Brucella suis, 11; Bacillus cereus, 15; B. polymyxa, Micrococcus pyogenes var. aureus, Mycobacterium tuberculosis, 50; B. subtilis, 75; Myco. smegmatis, 150; Aerobacter aerogenes, Br. bronchiseptica, Escherichia coli, Klebsiella pneumoniae, Salmonella paratyphi, S. pullorum, S. typhosa, 100-380. In vitro activity decreased by serum. [1]

TOXICITY LD_{50} in mice, approximately 900 mg/kg, i.p. [1] .

336. XANTHOCILLIN

SOURCE Penicillium notatum [1] .

MOLECULAR FORMULA $C_{18}H_{14}O_2N_2$ [1] .

CRYSTAL FORM AND COLOR Yellow clusters of needles[1]; yellow, rhombic prisms[2].[2]

MELTING POINT (°C) None; chars at 200.[1, 2]

SOLUBILITY sl. s. alcohol, ether, NaOH; i. water, benzene, chloroform. Dipotassium salt: s. water.[1]

STABILITY Thermo- and chemical stable.[1]

OTHER REACTIONS Contains 2 substances, X and Y, in ratio of 4:1; benzene ring and 2 phenol groups in molecule. Analysis: C, 72.93; H, 4.83; N, 8.64.[1, 2]

BIOLOGICAL ACTIVITY In vitro. Inhibits Micrococcus pyogenes var. aureus, Streptococcus spp, and Corynebacterium diphtheriae in low concentrations. Bacillus anthracis, Clostridum perfringens, Cl. tetani, Mycobacterium tuberculosis, Escherichia coli, Proteus spp, and Pseudomonas aeruginosa are also sensitive. In vitro. Bactericidal in low concentrations. Resistance did not develop readily. No cross resistance with penicillin or streptomycin [3] ; activity antagonized by streptomycin [4] .

/1/ From alcohol. /2/ From ethyl acetate.

336. XANTHOCILLIN (Concluded)

CLINICAL Local therapy with doses of 10-20 mg was of value in prophylaxis and the treatment of peritonitis. Larger amounts (350 mg) effective when inserted in large infected wound cavities, with no untoward reactions noted. Also topically used in infections of skin, eyes, and nasopharynx.[3]

PHARMACOLOGY Not readily absorbed; very low blood levels following oral and parenteral doses in animals [3] .

337. XANTHOMYCINS

SOURCE Streptomyces sp [1] .

NATURE Basic [1-3] .

MOLECULAR FORMULA $C_{23}H_{29-31}N_3O_7 \cdot 2HCl$ [3] .

CRYSTAL FORM AND COLOR HCl: bright orange-yellow, rectangular plates [3] . Free base: deep orange-red, amorphous solid [3] . Reineckate: long, orange needles [1] .

MELTING POINT (°C) Reineckate: 165-170 (d.) [1] .

OPTICAL ACTIVITY HCl: $[\alpha]_D^{25} = +115°$[1] [3] .

UV ABSORPTION MAXIMA HCl: 265, 345 mμ[2]. Free base: 288, 460 mμ[3].[3]

SOLUBILITY s. water, methanol, chloroform, butanol, acetone[4]; less s. ethyl acetate, amyl acetate, ether; i. cold water.[1, 2]

STABILITY Stable in acid solution; unstable at pH 6 and above; thermolabile, especially at pH 6 and above.[1, 2]

OTHER REACTIONS Continual change in aqueous phase to other active components of differing solubility; bitter taste; bright yellow in acid, deep reddish pink in dilute alkali; evanescent purple color with sodium ethoxide; positive Benedict, Br in CCl_4, $KMnO_4$, $AgNO_3$, acidified KI, sodium hydrosulfite, periodic acid; slight precipitate with 2, 4-dinitrophenylhydrazine and with dimedone; deep red with hydroxylamine; negative Sakaguchi, Molisch, ninhydrin, $FeCl_3$, nitroprusside, acidified stannous chloride, fuchsin, cysteine[5]; loss of color and activity with Adams platinic oxide catalyst; no loss of color with Thiele acetylation nor with chemical reductive acetylation; colorless crystalline product with catalytic reduction in acetic acid-acetic anhydride.[1-3] Hydrolysis with HCl yields ethanolamine, ammonia, methylamine, and a humin-like substance; oxidation of methyltetrahydroxanthomycin, a derivative, yields xanthomycinic acid I ($C_7H_{11}N_3O_{10}$), and II as the benzylisothiouronium salt ($C_4H_3O_3 \cdot C_8H_{10}N_2S$).[4] The hydrochloride of this salt has an optical rotation of $[\alpha]_D^{20} = +100$ (water), and an equivalent weight of 540 [5] .

QUANTITATIVE DETERMINATION Microbiological: Micrococcus pyogenes var. aureus (strain H) [1, 3] .

BIOLOGICAL ACTIVITY In vitro. Xanthomycin A picrate: Inhibits (dilution x 1, 000, 000) M. pyogenes var. aureus, 300; Bacillus subtilis, 240; B. niger, 200; Sarcina lutea, Alcaligenes viscosa, 40; B. mycoides, 28; B. vulgatus, 20; B. mesentericus, B. brevis, B. megatherium, Serratia marcescens, Aerobacter aerogenes, 4; Escherichia coli, Proteus vulgaris, Salmonella gallinarum, B. cereus, 2.4. Mycobacterium spp are insensitive.

Xanthomycin B picrate: Has similar antibacterial spectrum. [1]

Other preparations of xanthomycin inhibited (μg/ml) Klebsiella pneumoniae, 0.05; Shigella sonnei, 0.07; Salmonella schottmuelleri, 0.12; E. coli, 0.18; M. pyogenes var. aureus, 0 .003.[2]

TOXICITY Xanthomycin A HCl: LD_{50} in mice, 0.1-0.16 mg/kg, i.v. LD_0 in mice, 0.06 mg/kg, i.v.

Xanthomycin B: equally toxic.[1, 2]

338. XANTHOTHRICIN

SOURCE Streptomyces sp resembling S. albus [1] .

CRYSTAL FORM AND COLOR Yellow needles [1] .

MELTING POINT (°C) 165 [1] .

UV ABSORPTION MAXIMA 257.5, 390-402 mμ [1] .

SOLUBILITY s. water, chloroform, ethyl acetate, ethanol [1] .

OTHER REACTIONS Best extraction chloroform at pH 6.5; loss of yellow color at pH 10.5.[1]

/1/ c, 0.4 water. /2/ 0.1 N HCl. /3/ Absolute ethanol. /4/ Insoluble at acid pH. /5/ Cysteine stabilized activity.

338. XANTHOTHRICIN (Concluded)

QUANTITATIVE DETERMINATION Bacillus subtilis ATCC 6633 [1] .

BIOLOGICAL ACTIVITY *In vitro.* Inhibits (μg/ml) Salmonella typhosa, 1.56; Mycobacterium tuberculosis, 1.75-3.13; Escherichia coli, 3.1; Proteus vulgaris, 6.2; B. subtilis, Micrococcus pyogenes var. aureus, 12.5. Little or no activity against Pseudomonas aeruginosa and fungi.[1]

TOXICITY LD_{50} in mice, 1.7 mg/kg, i.v.; 8.4 mg/kg, oral.[1]

339. XEROSIN

Originally described as Antibiotic APM.

SOURCE Achromobacter xerosis, n. sp [2] .

UV ABSORPTION MAXIMUM 255-260 mμ[1] [1] .

STABILITY Stable at pH 9 for 45 minutes at 120°C [1] .

OTHER REACTIONS Analysis: N, 9.7-12.1; P, 2.1-2.7; positive biuret, anthrone; negative Fehling, Molisch, Millon, nitroprusside, ninhydrin, iodine; not destroyed by dialysis against running tap water for 24 hours nor by serial extraction with n-butanol and other organic solvents.[1]

BIOLOGICAL ACTIVITY No antibacterial activity in vitro or antiviral activity in chick embryos [2] . Inactive against type I poliomyelitis virus in tissue cultures [1] . No inhibition of influenza virus hemagglutination in vitro [2] . The antibiotic failed to protect HeLa cells in tissue cultures against cytotoxic effects of influenza A and B viruses [5] .

In vivo. Showed activity in mice infected with influenza A and B viruses, Newcastle disease, and mouse pneumonitis [1, 2] . Enhanced therapeutic effectiveness of chlortetracycline, oxytetracycline, and chloramphenicol in mice previously infected with mouse pneumonitis virus [1] . S. c. injection of xerosin produced delay in onset of tonic convulsions in mice previously infected intracerebrally with toxic amounts of influenza virus, but not when this virus was administered i.v. Neurotoxic action of influenza virus neutralized when small doses of antibiotic were administered by intracerebral route 1-3 days before, but not following, inoculation of virus by the same route.[4] No activity against Newcastle disease virus in chick embryos [6] . Intramuscular injection in chicks suppressed and modified the grossly invasive character of virus-induced Rous sarcoma. The inhibitory effect was slight when larger doses of virus were used to initiate the tumor.[7]

TOXICITY LD_0 in mice, 200 mg/kg, i.v.; 400 mg/kg, i.p.; 800 mg/kg, s.c. [1] Daily s.c. doses of 25-50 mg/kg poorly tolerated in guinea pigs [8] . Three daily injections of 2 mg into yolk sac were non-toxic in chick embryos [6] .

MODE OF ACTION Not only suppressed pneumonitis in mice initiated with viruses, but also inhibited development of lung lesions produced by chemical agents. Experimental evidence suggests that xerosin does not reduce damage to host cells by the virus, but rather inhibits host reactions of exudation, edema, and hemorrhage to this initial injury.[3] Pulmonary consolidation produced in mice by intranasal inoculation with capsular polysaccharide of Klebsiella pneumoniae (type B), or with xerosin itself, was inhibited by daily s.c. injection of 2 mg of the antibiotic. Subcutaneous injections of xerosin did not prevent the lethal effect of Newcastle disease virus upon Ehrlich ascites tumor cells in peritoneal cavity of mice. There was no evidence that the inhibitory action upon influenzal viral pneumonia in mice was related to a possible cortisone-like activity.[6] Parenteral injection of the antibiotic suppressed a pneumonia produced in mice by intranasal instillation of Escherichia coli endotoxin, as well as that produced with the toxic factor of Newcastle disease virus [9] . Xerosin posesses anti-inflammatory properties. Daily s.c. doses of 20 mg in guinea pigs reduced the tuberculin reaction, the reversed passive Arthus reaction and the inflammatory response to turpentine and urease, but did not modify the histamine wheal [8] .

340. ZAOMYCIN

SOURCE Streptomyces zaomyceticus, n. sp.

MELTING POINT (°C) 242-246 (d.) [1] .

SOLUBILITY s. methanol, ethanol, dilute alkali, acid; sl. s. water; i. most organic solvents.[1]

STABILITY Unstable dry, accompanied by a change of color to dark violet; unstable in water, but more stable at pH 7-8.[1]

OTHER REACTIONS Resembles amphomycin; positive ninhydrin, Millon, biuret, $FeCl_3$ (reddish-brown); negative Fehling, Liebermann; brown precipitate on addition of concentrated H_2SO_4.[1]

BIOLOGICAL ACTIVITY *In vitro.* Inhibits (μg/ml) Bacillus subtilis, B. agri, Mycobacterium smegmatis, 0.8; B. anthracis, Gaffkya tetragena, 1.5; Micrococcus pyogenes var. aureus, Streptococcus pyogenes, Diplococcus

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/1/ Aqueous solution.

pneumoniae, 3.0. Mycobacteria, Gram-negative bacteria, and fungi not sensitive to 100 μg/ml. Protozoa: Trichomonas foetus inhibited by 60 μg/ml.[1]

TOXICITY LD_0 in mice, 0.3 mg/kg, i.v.[1]

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APPENDIX

APPENDIX I: ANTIBIOTIC EFFICACY, A LISTING BY ORGANISM

The organisms listed below appear in the body of the volume, thus this is not a supplementary listing. Alphabetization, rather than taxonomic grouping, has been employed for convenience of the user. Numbers immediately following the name of the organism identify the antibiotics and are in ascending numerical order--not in order of preference or effectiveness. Antibiotics so indicated have, according to the text of this volume, demonstrated moderate to marked efficacy against that organism.

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APPENDIX II: ANTIBIOTIC SOURCES, A LISTING BY ORGANISM

Source microorganism(s) for each of the 340 antibiotics are listed in the text. These data have been rearranged here, by organism rather than by antibiotic. The name of each organism is followed by the name(s) of antibiotics for which it is a source. Underscored numbers are the identifying item numbers of antibiotics as they appear in the book.

Acetobacter spp	Kojic acid, 174
Achromobacter xerosis	Xerosin, 339
Aerobacter aerogenes	Coliformin, 90
Agrocybe dura	Agrocybin, 12
Alternaria solani	Alternaric acid, 16
	Alternarine, 17
Alternaria tenuis	Alternariol, 18
Aspergillus spp	Citrinin, 85
	Granegillin, 147
	Kojic acid, 174
	Mycocidin, 201
	Patulin, 235
	Penicillic acid, 236
	Penicillins, 237
Aspergillus candidus	Candidulin, 58
Aspergillus flavus	Aspergillic acid, 31
Aspergillus fumigatus	Fumagillin, 128
	Fumigatin, 129
	Gliotoxin, 140
	Helvolic acid, 159
	Spinulosin, 288
Aspergillus humicola	Humicolin, 164
Aspergillus melleus	Mellein, 189
Aspergillus nidulans	Nidulin, 215
	Nor-nidulin, 215
Aspergillus ochraceus	Mellein, 189
Aspergillus oryzae	Oryzasizine, 231
Aspergillus parasiticus	Aurantidin, 32
Aspergillus tamaris-oryzae	Kojic acid, 174
Aspergillus terreus	Geodin, 136
	Terrecin, 304
	Terreic acid, 305
Bacillus spp	Fungistatin, 131
	Gramicidin S, 146
Bacillus alvei	Alvein, 19
Bacillus brevis	Brevin, 50
	Brevolin, 51
	Gramicidin, 144
	Gramicidin J, 145
	Tyrocidine, 320
	Tyrothricin, 321
Bacillus cereus	Biocerin, 47
Bacillus circulans	Circulin, 84
	Polypeptin, 250
Bacillus krzemieniewski	Polypeptin, 250
Bacillus laterosporus	Laterosporins, 177
Bacillus licheniformis	Bacitracins, 45
	Licheniformins, 182
Bacillus mesentericus	Esperin, 110
Bacillus polymyxa	Polymyxins, 249
Bacillus pumilus	Pumilin, 258
	Tetaine, 308
Bacillus simplex	Simplexin, 286
Bacillus subtilis	Bacilipins, 39
	Bacillin, 40
	Bacillomycin, 41
	Bacillomycin B, 42
	Bacilysin, 44
	Bacitracins, 45
Bacillus subtilis (concluded)	Eumycin, 115
	Fluvomycin, 122
	Globicin, 141
	Iturins, 172
	Mycosubtilin, 205
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Cephalothecium sp	Cephalothecin, 72
Chaetomium cochlioides	Chetomin, 76
Chromobacterium sp	Chlororaphin, 79
Chromobacterium iodinum	Iodinin, 170
Chromobacterium violaceum	Violacein, 328
Clitocybe candida	Clitocybins, 87
Clitocybe diatreta	Diatretynes, 100
Clitocybe illudens	Illudins, 168
Clitocybe nebularis	Nebularine, 208
Coprinus quadrifidus	Quadrifidins, 264
Coprinus similis	5-Methoxy-p-toluquinone, 191
Cordyceps militaris	Cordycepin, 95
Drosophila substrata	Drosophilins, 102
Escherichia coli	Colicines, 89
	Coliformin, 90
Fomes juniperinus	Fomecin A, 123
Fusarium spp	Chlamydosporin, 77
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Fusarium bostrycoides	Bostrycoidin, 49
Fusarium javanicum	Javanicin, 173
Fusarium orthoceras	Enniatin A, 106
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Ganoderma oregonense	Oregonensin, 230
Gibberella baccata	Baccatine A, 38
Gibberella fujikuroi	Fusaric acid, 132
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Lentinus degener	5-Methoxy-p-toluquinone, 191
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Marasmius conigenus	Marasmic acid, 186
Marasmius graminum	6-Methyl-1,4-naphthaquinone, 192
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	Nocardamin, 219
	Nocardianin, 220
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	Streptocardin, 290
Nocardia acidophilus	Mycomycin, 203
Nocardia formica	Noformicin, 222
Nocardia gardneri	Proactinomycins, 254
Nocardia kuroishi	Neonocardin, 213
Nocardia mesenterica	Azomycin, 37
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Penicillium albidum	Albidin, 13
Penicillium brevi-compactum	Mycophenolic acid, 204
Penicillium canescens	Canescin, 59
Penicillium carneo-lutescens	Carneolutescin, 63
Penicillium citrinum	Citrinin, 85
Penicillium cyclopium	Cyclopaldic acid, 97
	Viridicatin, 331
Penicillium daleae	Kojic acid, 174
Penicillium frequentans	Citromycetin, 86
	Frequentin, 127
Penicillium funiculosum	Helenine, 157
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A term appearing by itself--i.e., not followed by another in parentheses--in the index appears as such in the text. A term followed by another term in parentheses in the index appears in the text as the parenthetical term. Each antibiotic covered in the text is assigned an item number, so that each term in the index is followed by an underscored number--the item number--separated by a colon from a second number or numbers--the page number(s). For example:

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indicates that the antibiotic Actinoleukin is item 4 and is found on pages 3 and 4; and

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shows that the antibiotic Ochracin is listed in the text as Mellein, item 189 on pages 109 and 110.

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